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Stochastic reconstruction of precipitation fields for Germany using information from a country-wide network of Commercial Microwave Links

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Precipitation is one of the crucial variables within the hydrological system, and accordingly one of the main drivers for terrestrial hydrological processes. The quality of hydrological applications such as climate prediction, water resource management, and flood forecasting, depends on the correct reproduction of its spatiotemporal distribution as well as the estimation of uncertainties introduced by the usage of observational data. In order to address these challenges, we apply Random Mixing to stochastically simulate precipitation fields. We generate precipitation fields 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 optimized in such a way that the observations and the spatial structure of the precipitation observations are reproduced. Our main innovation is the ability to simulate precipitation field ensembles of any size, where each ensemble member is in concordance with the underlying observations. As observations we use path-averaged rain rates, derived from attenuation data provided by a country-wide network of Commercial Microwave Links (CMLs). The difficulty when using path-averaged rain rates is that CMLs give non-linear constrains for the precipitation field in contrast to point information which give linear constrains. Therefore, based on the CML observations, we sample sets of observation points located along the CML paths. These sets of observation points are used to calculate the spatial dependence structure of the precipitation fields. Consequently, the generation of the ensemble is based on various sets of sampled observation points. The spread of such an ensemble allows for an uncertainty estimation of the generated precipitation fields and reflects the uncertainty of rainfall variability along the CML paths. For the demonstration of this strategy we use CML observations over the area of Germany. We show that the reconstructed precipitation fields reproduce the observed spatial precipitation pattern in a comparable good quality as the RADOLAN-RW data set provided by the German Weather Service. Further, we discuss the influence of the observation network topology on the uncertainty estimation, as illustrated by the uneven spread of CML observations over Germany.