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Large-Scale Weather Generator for Downscaling Precipitation

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Well parametrized distributed precipitation-runoff models are able to correctly quantify hydrological state variables (e.g. streamflow, soil moisture, among others) for the past decades. In order to estimate future risks associated with hydrometeorological extremes, it is necessary to incorporate information about the future weather and climate. A common approach is to downscale Regional Climate Model (RCM) projections. Therefore, various statistical downscaling schemes, utilizing diverse mathematical methods, have been developed.

One kind of statistical downscaling technique is the so called Weather Generator (WG). These algorithms provide meteorological time series as the realization of a stochastic process. First, single- and multi-site models were developed. Recently, however WG at sub-daily scales and on gridded spatial resolution have captured the interest because of the new development in distributed hydrological modelling. A standard approach for a multi-site WG is to sample a multivariate normal process for all locations. Doing so, it is necessary to calculate the Cholesky factor of the cross-covariance matrix to guarantee a spatially consistent sampling. In general, gridded WGs are an extension of multi-site WGs to larger domains (i.e. $>$10000 grid cells). On these large grids, it is not possible to accurately determine the Cholesky factor and further enhancements are required.

In this work, a framework for a WG is proposed, which provides meteorological time-series on a large scale grid, e.g. 4 km grid of Germany. It employs a sequential Gaussian simulation method, conditioning the value of a grid cell only on a neighborhood, not on the whole field. This methodology is incorporated into a multi-scale downscaling scheme, which is able to provide precipitation data sets at different spatial and temporal resolutions, ranging from 4 km to 32 km, and from days to months, respectively. This framework uses a copula approach for spatial downscaling, exploiting the strong dependence between different spatial scales, and a multiplicative cascade approach for the temporal disaggregation.

This study incorporates a gridded, daily data set for the domain of Germany at a 4 km resolution. The data set was interpolated by external drift kriging of station data from the German Weather Service (DWD) and spans over the time period from 1961 to 2000. The data set was aggregated to the different spatio-temporal scales resolutions investigated in this study.

The proposed methodology provides precipitation time series at the resolution and grid sizes required by large hydrological application (at national level). First results indicate that the framework is able to consistently preserve precipitation statistics including variability at multiple spatio-temporal resolutions. Nevertheless, it has to be investigated, whether rainfall extremes are correctly represented.