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Physically coherent probabilistic weather forecasts via discrete copula-based ensemble postprocessing methods

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State-of-the-art weather forecasts depend on ensemble prediction systems, which consist of multiple runs of dynamical numerical weather prediction models differing in the initial conditions and/or the parameterized numerical representation of the atmosphere. Statistical postprocessing of the ensemble forecasts can address biases and dispersion errors. However, current postprocessing approaches are mostly univariate and apply to a single weather quantity at a single location and for a single prediction horizon only. Such methods do not account for dependencies which are crucial in many applications.

Multivariate postprocessing approaches based on empirical copulas offer appealing options to address this.
The ensemble copula coupling (ECC) method uses the empirical copula of the raw ensemble to aggregate samples from predictive distributions obtained by univariate postprocessing. It captures the spatial, temporal and inter-variable rank dependence pattern of the unprocessed raw ensemble.
Proceeding in a similar manner, the Schaake shuffle alternatively captures dependence structures of past observations rather than ensemble forecasts. A specific implementation of the Schaake shuffle employs historical observation data from past dates for which the corresponding ensemble forecast resembles the current one.

The methods are illustrated and tested using real weather forecast data provided by the European Centre for Medium-Range Weather Forecasts.