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COBASE: A new copula-based shuffling method for ensemble weather forecast postprocessing

Elisa Perrone[1], Maurits Flos[2], Bastien François[3], **Irene Schicker**[4], and Kirien Whan[5]
[1]Eindhoven University of Technology, Mathematics and Computer Science, the Netherlands (e.perrone@tue.nl)
[2]Eindhoven University of Technology, Mathematics and Computer Science, the Netherlands (m.g.j.flos@student.tue.nl)
[3]Royal Netherlands Meteorological Institute, De Bilt, the Netherlands (b.francois@knmi.nl)
[4]GeoSphere Austria, Vienna, Austria (irene.schicker@geosphere.at)
[5]Royal Netherlands Meteorological Institute, De Bilt, the Netherlands (k.whan@knmi.nl)

Weather predictions are often provided as ensembles generated by repeated runs of numerical weather prediction models. These forecasts typically exhibit bias and inaccurate dependence structures due to numerical and dispersion errors, requiring statistical postprocessing for improved precision. A common correction strategy is the two-step approach: first adjusting the univariate forecasts, then reconstructing the multivariate dependence. The second step is usually handled with nonparametric methods, which can underperform when historical data are limited. Parametric alternatives, such as the Gaussian Copula Approach (GCA), offer theoretical advantages but often produce poorly calibrated multivariate forecasts due to random sampling of the corrected univariate margins. In this work, we introduce COBASE, a novel copula-based postprocessing framework that preserves the flexibility of parametric modeling while mimicking the nonparametric techniques through a rank-shuffling mechanism. This design ensures calibrated margins and realistic dependence reconstruction. We evaluate COBASE on multi-site 2-meter temperature forecasts from the ALADIN-LAEF ensemble over Austria and on joint forecasts of temperature and dew point temperature from the ECMWF system in the Netherlands. Across all regions, COBASE variants consistently outperform traditional copula-based approaches, such as GCA, and achieve performance on par with state-of-the-art nonparametric methods like SimSchaake and ECC, with only minimal differences across settings. These results position COBASE as a competitive and robust alternative for multivariate ensemble postprocessing, offering a principled bridge between parametric and nonparametric dependence reconstruction.