



A Composite-Loss Graph Neural Network for the Multivariate Post-Processing of Ensemble Weather Forecasts

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A widely recognized limitation of most post-processing methods is that they are typically applied independently for each forecast horizon, location, and variable, potentially neglecting important dependencies across these dimensions. Despite the development of numerous statistical and machine learning methods for modeling these dependencies, the topic remains the subject of ongoing research.

In this work, the proposed approach employs a graph neural network (GNN) trained with a composite loss function that combines the energy score (ES) and the variogram score (VS) for the multivariate postprocessing of ensemble forecasts. The method is evaluated using WRF-based solar irradiance forecasts over northern Chile and ECMWF visibility forecasts over Central Europe. Across all multivariate verification metrics, the dual-loss GNN consistently outperforms empirical copula-based postprocessing methods as well as GNNs trained solely with CRPS or ES. For the WRF forecasts, the learned rank-order structure captures dependency information more effectively, leading to improved restoration of spatial relationships compared with both the raw ensemble and historical observational ranks. Moreover, incorporating VS into the training loss also improves univariate predictive performance for both forecast targets.

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