Improving the CFSv2 Seasonal Precipitation Forecasts across the United States by Combining Weather Regimes and Gaussian Mixture Models

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Although seasonal climate forecasts have major socioeconomic impacts, current forecast products, especially those for precipitation, are not yet reliable for forecasters and decision-makers. Here we developed a novel statistical–dynamical hybrid model for precipitation by applying weather regimes (WRs) and Gaussian mixture models (WR-GMM) to the National Oceanic and Atmospheric Administration's Climate Forecast System, version 2 (CFSv2), precipitation forecasts across the continental United States. Instead of directly forecasting precipitation, WR-GMM uses observed precipitation from synoptic patterns similar to the future CFSv2 forecast. Traditionally *K*-means has been used to classify daily synoptic patterns into individual WRs, but the new GMM approach allows multiple WRs to be represented for the same day. The novel WR-GMM forecast model is trained on daily Climate Forecast System Reanalysis (CFSR) geopotential height and observed precipitation data during the 1981–2010 period and is verified for 2011–22. Overall, the WR-GMM method outperforms the CFSv2 ensemble forecast precipitation in terms of root-mean-square error and for Pearson correlation coefficient for lead months 1–4. Previous studies have used global climate models to forecast WRs in the Pacific Ocean and Mediterranean Sea regions, usually with an emphasis on winter months, but the WR-GMM model is the first of its kind that promises great untapped potential to improve precipitation forecasts produced by CFSv2 across the continental United States.