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Spatial mode-based calibration of forecast precipitation fields from numerical weather prediction models

Pengcheng Zhao, Quan J. Wang, Wenyan Wu and Qichun Yang

Department of Infrastructure Engineering, The University of Melbourne, Australia
Email: quan.wang@unimelb.edu.au

Abstract: Statistical calibration of precipitation forecasts from numerical weather prediction (NWP) models is routinely performed grid-cell by grid-cell, aiming to produce accurate and reliable ensemble forecasts for precipitation fields. Calibrated ensemble members from different grid-cells are then connected using ensemble reordering to form spatially structured ensemble forecasts. However, ensemble reordering approaches are often found to be problematic in practice. For example, the well-known Schaake shuffle is generally criticized for not considering real physical atmospheric states of precipitation events (Bellier et al., 2017).

To overcome limitations with ensemble reordering, this study proposes a spatial mode-based calibration (SMoC) model for post-processing forecast precipitation fields and producing ensemble forecasts with inbuilt spatial structures, so that ensemble reordering is not required (Zhao et al., 2022). The SMoC model is developed based on spatial modes derived from empirical orthogonal function (EOF) analyses of precipitation fields and linear regressions of derived EOF expansion coefficients of the first few dominant modes. Distributions of regression residuals are used to quantify associated forecast uncertainty. Unlike calibration models that are applied to forecast grid-cells individually, SMoC is applied to the whole forecast fields, and the spatial structure is therefore inherently present in calibrated ensemble forecasts.

The performance of SMoC is evaluated by applying it to NWP precipitation forecasts over the Brisbane drainage basin in eastern Australia and comparing it with post-processing through calibrations grid-cell by grid-cell using the seasonally coherent calibration model (Wang et al., 2019) followed by ensemble reordering using the Schaake shuffle (Clark et al., 2004). Results show that SMoC calibrated forecasts are of high quality at both grid-cell and basin scales and the spatial structure is well embedded in calibrated ensemble members. Compared with the conventional post-processing, SMoC avoids drawbacks of ensemble reordering, is computationally far more efficient, and most importantly leads to better forecast performance. As a significant advance in forecast post-processing, SMoC can affectively improve users' capability in acquiring high-quality ensemble forecasts of precipitation fields.

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