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Multi lead time parameter inference for post-processing precipitation forecasts

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Abstract: Statistical post-processing methods are pivotal for generating ensemble forecasts that are unbiased, coherent, and reliable across different lead times and spatial-temporal accumulations. However, these methods typically require extensive archives of historical forecasts and concurrent observations, which can be challenging to obtain due to rapid evolution and high computational demands of high-resolution Numerical Weather Prediction (NWP) models needed to produce retrospective forecast. As a result, long forecast archives are often unavailable when new NWP models become operational.

Most post-processing methods establish models separately for individual lead times (Robertson et al., 2013). This results in numerous parameters sets that can be incoherent across lead times, especially when only short records of NWP forecasts are available. The catchment-scale hydrological precipitation pre-processing method (CHyPP, Shrestha et al., 2015) currently used by the Bureau of Meteorology in its 7-day ensemble forecasting service (Hapuarachchi et al., 2022), follows this approach by inferring parameters independently for each lead time. To address limitations arising from separate lead-time inference, we introduce a novel extension called CHyPP-GL (generalised across lead time), which enhances the robustness of post-processing under limited forecast archives. By analysing CHyPP parameters estimated individually for specific lead times, we identify that some parameters are strongly related to lead time and time of day. We leverage these relationships to reformulate parameter inference, accounting for (i) diurnal variations in the marginal distributions of NWP forecasts and observed precipitation, and ii) the consistent decline in forecast-observation correlation with lead time. CHyPP-GL infers parameters jointly across multiple lead times, making it more parsimonious and better suited to operational applications.

To evaluate the performance of CHyPP-GL, we applied it to rainfall forecasts from the ACCESS-G model for two contrasting catchments in Australia: the Daly River catchment in the tropical north and the Ovens River catchment in the temperate southeast. To assess robustness, models were trained with datasets of different lengths (3, 6, 12 and 24 months). Comparative analyses show that CHyPP-GL performs similarly to the original parameter inference approach under cross-validation when extensive NWP archives are available. However, with shorter records, CHyPP-GL improves accuracy, reliability and reduces bias, making post-processing more practical for operational use in data-limited situations.

One limitation of CHyPP-GL is that it assumes a constant proportion of censored values at all lead times when estimating transformations. In this study we have applied CHyPP-GL to a deterministic NWP, where this assumption holds. However, ensemble means do not necessarily conform to this assumption (Shrestha et al., 2020). We discuss this problem and propose methods to address it.

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