Statistical Bias Correction of NCMRWF Unified Model Precipitation Forecasts Based on Quantile Mapping Methods

Kondapalli Niranjan Kumar, Sukhwinder Kaur, Shubha Singh, Mohana Satyanarayana Thota, Raghavendra Ashrit, Ashis K. Mitra & V S Prasad

National Centre for Medium Range Weather Forecasting, Ministry of Earth Sciences, Noida,

India Email: niranjan.kondapalli@gov.in

1. Introduction

The model forecasts frequently show systemic errors in relation to the observations and, more significantly, in relation to the crucial variables, like precipitation. Thus, it is essential to correct the model errors to efficiently utilize NWP forecasts for decision-making applications for flood risk management. In this study, we particularly focused on the assessment of location-specific bias correction methods for Mumbai (BOM, 72.85^{o}E, 19.117^{o}N), located on India's western coast. This location is chosen here to support the Integrated Flood Warning System (IFLOWS), initiated by the Ministry of Earth Sciences, Government of India, which provides early warning and decision support during flooding. Mumbai city experiences strong westerly and southwesterly flow because of summer monsoon winds from the Arabian Sea because of its geographic location on the windward side of the Western Ghats of India. This causes orographic rainfall with a high magnitude and intensity. In addition, the city is also affected by other significant weather features including offshore vortices and troughs, depressions in the Arabian Sea, and most significantly, mid-tropospheric cyclones (MTCs), which bring hazardous rainfall during the southwest monsoon. The novelty and significance of this work lie in using a newly developed high-resolution Indian Monsoon Data Assimilation and Analysis (IMDAA, Rani et al., 2012) reanalysis product in calibrating the National Centre for Medium Range Weather Forecasts (NCMRWF) Unified Model (NCUM) operational forecasts (Sumit Kumar et al., 2021) for improving rainfall forecasts at a local scale. The NWP dynamical cores used to generate the IMDAA reanalysis data and the NCUM daily operational forecasts are quite similar. Hence, as they employ the same model physics, IMDAA can be efficiently used to correct real-time forecasts. It is also important to note that the calibration methods adjust the model's systematic biases which are equivalent to many years of improvement to the basic model.

2. Methodology

Statistical bias correction techniques establish a link/relationship between observed and simulated variables over the historical period and then utilize the functional relationship to bias-correct the model predictions. In this study, we used empirical quantile mapping (EQM), parametric quantile mapping (PQM), and gamma/generalized Pareto parametric quantile mapping (GPQM) techniques (Niranjan Kumar et al., 2021). EQM is a non-parametric bias correction method that calculates quantile-by-quantile modifications/changes in the simulated cumulative distribution function to correct the mean and variability, including shape errors. However, PQM and GPQM are parametric bias correction techniques. The PQM technique assumes that both observed and simulated intensities are well approximated with two-parameter gamma distributions and uses a theoretical distribution rather than an empirical distribution. While the GPQM method is based on gamma distribution combined with generalized Pareto distribution (GPD).

3. Quantile Mapping Bias Correction

Figure 1 (left panel) shows the time evolution of India Meteorological Department (IMD) station rainfall (OBS), NCUM Day-1 raw forecasts (FCS), and bias-corrected Day-1 rainfall forecasts based on EQM (FCS_{eqm}), PQM (FCS_{pqm}), and GPQM (FCS_{gpqm}) methods. The observed rainfall over BOM indicates heavy to very heavy rainfall events (>64.5mm/day) defined by IMD during the southwest monsoon season (JJAS 2022). Figure 1 (right panel) indicates skill scores based on raw and bias-corrected forecasts. Figure 1 (right panel) depicts the HIR (Hit rate), and ETS (Equitable threat score) scores for bias-corrected forecasts that have higher magnitudes for rainfall events with magnitudes more than 100mm/day along with low False alarm rate (FAR). Hence, the heavy to very heavy rainfall events are better calibrated based on the parametric methods which will be useful for early warning and decision support for flooding during extreme rainfall events over the Mumbai city. The results from our study indicate that the GPQM performance is relatively better while correcting the raw forecasts, especially, during heavy rainfall cases.

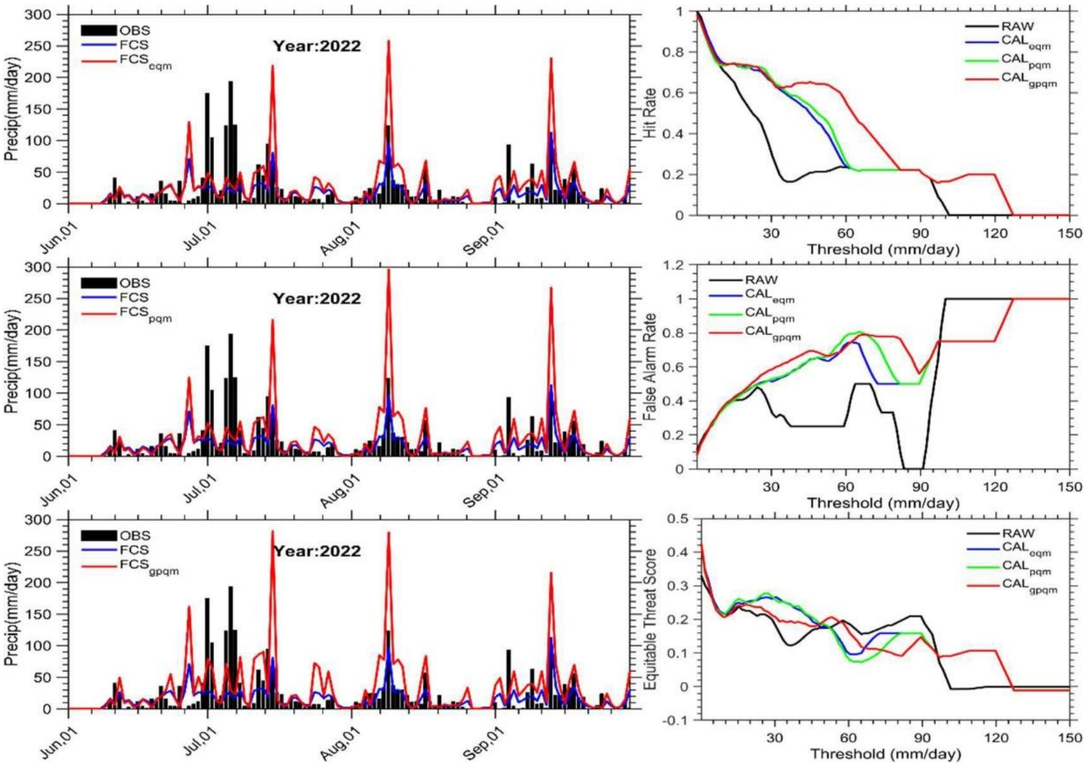

Figure 1 (left panel) Time evolution of observed and model forecast rainfall along with calibrated rainfall based on quantile mapping bias-correction methods for the period between Jun-Sep, 2022. (Right panel) Model skill scores such as Hit Rate (HIR), False Alarm Rate (FAR), and Equitable Threat Score (ETS) are estimated based on IMD station rainfall vs raw and bias-corrected model forecasts.

4. References

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