Government of Nepal
Ministry of Energy, Water Resources and Irrigation
Water Resources Research and Development Centre
Pulchowk, Lalitpur

WRRDC RESEARCH LETTER
Issue: 23
August 2022

Performance Evaluation of Climate Models and Bias Correction Methods in Tila River Basin

Background

Projections from the climate models are widely used for climate change impact assessment. The new state-of-the-art Coupled Model Intercomparision Phase 6 (CMIP6) models provide a better opportunity to improve the characterization of hydroclimatic processes through refined parameterization schemes for major biogeochemical and physical climate systems (Eyring et al., 2016). General Circulation Model (GCM) are accompanied with uncertainties and biases. GCM outputs cannot be directly used in climate change impact assessment since they contain systematic errors. Also, the spatial and temporal heterogeneity of climatic variables in the Himalayas is a challenge for GCM. This study evaluates the performance of CMIP6 GCM and bias correction method (BCM) in capturing climate characteristics of Tila river basin, located in the central Himalayas (Figure 1). We evaluate climatic data of 13 GCM outputs from Mishra et al. (2020). Since these data are corrected and downscaled at 25 km resolution using gridded data for the region outside India, we employ another level of bias correction using ground-based gauged data.

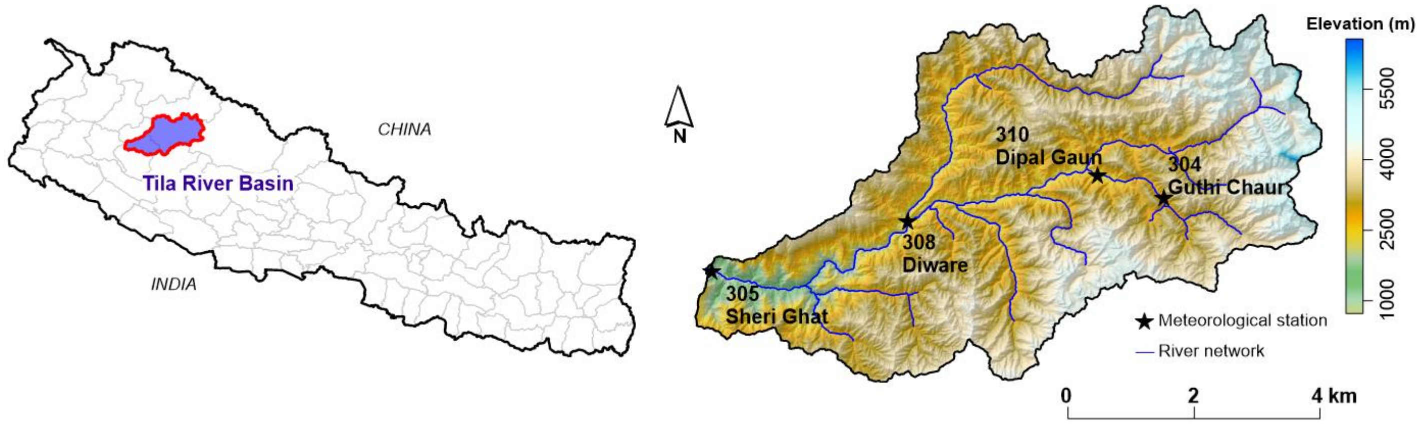

Figure 1: Study area map showing the location of meteorological stations.

Methodology

We bias-correct the retrieved precipitation (PCP), maximum temperature (Tmax), and minimum temperature (Tmin) data at local level relative to monthly climatic data at each meteorological location using ten different methods. Using the *qmap* package on the R environment (Gudmundsson, 2016), we applied the six parametric and three non-parametric transformation: Empirical Quantile Mapping (EQM), Empirical Robust Quantile Mapping (ERQM), Empirical Smoothing Spline (ESS). In linear scaling (LS) approach, we apply the multiplicative (additive) monthly correction factors to obtain bias-corrected precipitation (temperature). We evaluate the performance of GCM and BCM based on its ability to capture historical climate pattern by comparing the raw and bias-corrected GCM output with the monthly observation from 1988 to 2013. NSE, RSR, and percentage bias (PBIAS) are used as performance metrics. At first, we compute the performance metrics of each model at all of the meteorological stations and convert them into arbitrary performance ratings based on Moriasi et al. (2007). Ranking is done based on the average of combined ratings of all metrics over all selected stations using a pool of thirteen GCMs and ten BCMs.

Results

All the GCMs shows satisfactory performance in capturing the tendency of Tmin as that of observed DHM monthly time series. However, raw GCM precipitation and Tmax are not in good agreement with the local station values. Primarily, all the GCM failed to replicate precipitation for Diware (station 308). They exhibit negative NSE, higher RSR and overestimation of monthly precipitation. Among 13 GCMs, ACCESS-ESM1-5 and CanESM5 are ranked the first and last, respectively according to the overall performance rating in case of precipitation (Figure 2a). MPI-ESM1-2-LR outperforms other GCMs in capturing the Tmin.

After applying bias correction, corrected data captured the variability at all stations. Both positive and negative corrections are needed for precipitation and temperature at different months at different stations. **Among 10 BCMs,** LS and ERQM are ranked first and last, respectively according to the overall performance rating **in case of precipitation** (Figure 2b). All the BCMs corrected the temperature (min and max) to a greater extent with average rating greater than 4.

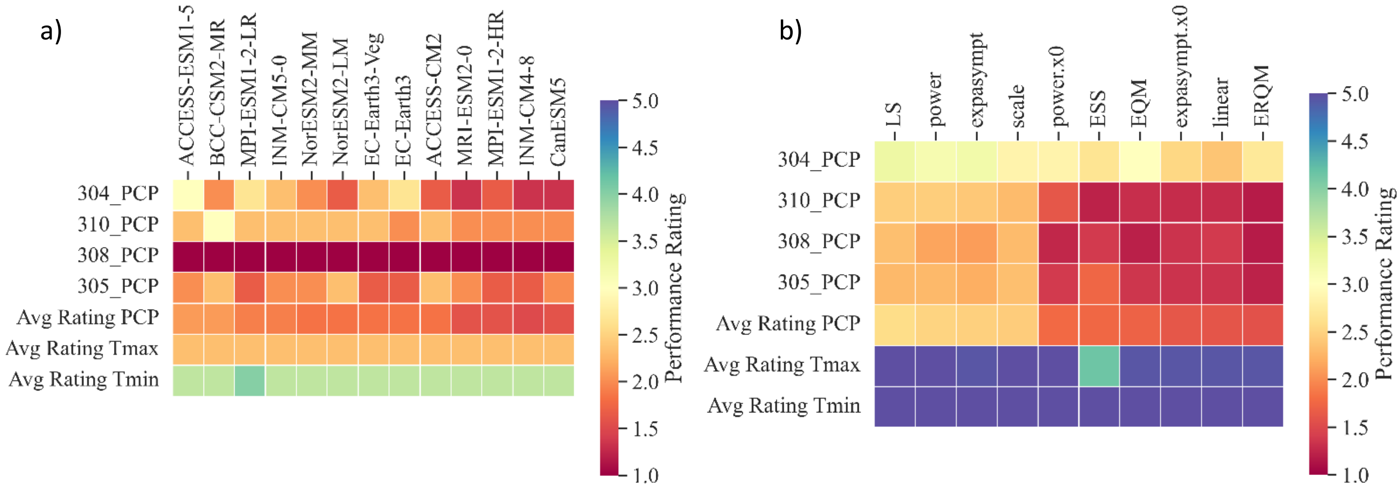

Figure 2: Overall performance rating of (a) GCM and (b) BCM.

Remarks

Before employing our correction, the data retrieved from Mishra et al. (2020) are not well capturing the ground reality. CanESM5 GCM exhibit poor performance in almost all case, even after bias correction. It is recommended to use linear scaling method for bias correction at monthly resolution. Linear scaling approach is applicable for bias correction at monthly resolution. Future research could focus on using bias corrected data as an input to force hydrologic model for climate change impact assessment.

Acknowledgement

We would like to acknowledge Department of Hydrology and Meteorology (DHM), Nepal for sharing the meteorological ground observations and Mishra et al. (2020) for CMIP6 data, for South Asia, including Nepal.

Reference

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FOR FURTHER INFORMATION:

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Citation: Pradhan, A.M.S., Baniya, R., Regmi, R.K., Talchabhadel, R., Sharma, S., Panthi, J., Ghimire, G.R., Bista, S., Thapa, B.R. 2022. Performance Evaluation of Climate Models and Bias Correction Methods in Tila River Basin, WRRDC Research Letter, Issue no: 23, August 2022, pp. 1-2.