Inter-comparison of gauge-adjusted global satellite rainfall estimates for water resources management in the Meghna river basin

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Bangladesh suffers floods almost every year in the Meghna river basin. It is a transboundary basin that is originated in India and extends to the north-eastern part of Bangladesh. Hydro-meteorological and water use data that are essential dynamics for efficient water resources management, are not being shared between the two countries, and water-related disasters, particularly, frequent floods in the basin, cause fatalities and agricultural losses resulting in numerous socio-economic damages. To address this issue, this research focused on the applicability of globally available satellite-based rainfall estimates that are lately seen as a suitable alternative for climatic and hydrological applications. This study aims to evaluate four Gauge adjusted Satellite Rainfall Products (GSRPs) e.g. Climate Hazards group InfraRed Precipitation with Station data (CHIRPS), Global Satellite Mapping of Precipitation with Gauge correction (GSMaP-Gauge), Tropical Rainfall Measuring Mission Version 7 (TRMM-3B42V7), and Multi-Source Weighted-Ensemble Precipitation (MSWEP), identify their errors against the available ground rainfall data within Bangladesh. The study further applied bias correction and merging techniques to remove the errors and investigate their potential to be used as a reference gridded data in simulating hydrological responses of the Meghna river basin at the critical discharge locations within Bangladesh.
The inter-comparison of GSRPs was performed for the wet season at twenty rain gauge stations located inside Bangladesh domain of the basin. The results showed that they have similarities as well as differences in producing errors. All products have significant weaknesses in detecting the magnitude and spatiotemporal distribution of rainfall. CHIRPS mostly overestimated the rainfall, while GSMaP-Gauge underestimated it, and the rests TRMM-3B42V7 and MSWEP showed varying performance with both over- and under- estimation at the gauge locations. The errors were resulted with values of higher normalized-mean-squared error (NMSE) and root-mean-squared error (RMSE), larger relative bias (RB), and lower correlation coefficient (CC) for daily scale comparison than the monthly scale. A number of bias removing techniques i.e. Linear Correction, Quantile Mapping, and a modified linear correction (MLC) method introduced by this study were applied to the GSRPs to improve their performance. The MLC was better against other two correction methods and removed the systematic bias from the GSRPs partially that can be attributed to the sparse distribution of gauges and very low correlations between daily gauge and daily GSRP estimates. Subsequently, merging of the GSRPs was explored with three merging techniques named as Simple Averaging (SA), Error Variance (EV), and Inverse Error Variance Weighting (IEVW). Merging improved the data accuracy than the individual product and IEVW technique was found to provide best results. The best dataset, among the bias corrected and merged products, was used to drive a hydrological model called Rainfall-Runoff-Inundation (RRI) to investigate its applicability in simulating streamflows over the Meghna. The dataset reproduced the timing and volume of streamflows as well as the seasonal, annual, peak and low flows reasonably well indicating that it has the potential in accurate streamflow generation over the basin. Therefore, this dataset can be used for climatic and long-term hydrological applications in the Meghna river basin.

Keywords: Transboundary river, Meghna, reference rainfall dataset, satellite rainfall, bias correction, merging

