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Satellite-based Hydrological Model (SHM): Quantification of Uncertainty in Streamflow Simulation

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A large-scale conceptual hydrological model, viz., Satellite-based Hydrological Model (SHM), has been developed for the entire landmass of India. The model has a grid cell resolution of 5 km $\times$ 5 km. It has five modules: Surface Water (SW), Forest (F), Snowmelt (S), Groundwater (GW), and Routing (ROU). SHM has been manually calibrated and validated for daily streamflow simulations in seven sub-basins of five Indian river basins, Baitarani, Brahmani, Kabini, Kangsabati, and Subarnarekha. Subsequently, to check the reliability of the newly developed model, we have performed the uncertainty analysis using the simulated streamflow using the quantile regression (QR) technique, which considers all sources of error. After quantifying the upper and lower limit of the 95 percent prediction uncertainty (PPU) band, we have estimated the 'p-value' and 'r-value' and plotted 'p-value'vs. 'r-value' graph for all basins (for calibration and validation periods separately). 'p-value' represents the observed data bracketed by the 95PPU band, and 'r-value' expresses the relative length of the 95PPU band with respect to the model simulated values.Both 'p-value' and 'r-value' vary between 0 and 1, 'p-value' equal to '1' and 'r-value'equal to '0' representing the model simulation with no uncertainty.Results show that most of the observed data fall within 95% confidence interval bands, during both calibration and validation periods, which indicate the accuracy of the error model. The analysis of 'p-value'vs. 'r-value' graphs shows that the uncertainty is the least in case of the Muri gauging station (forest land cover =6.90%) of the Subarnarekha basin(p-value: 0.63 and r-value: 0.22 during calibration, and p-value: 0.76 and r-value: 0.11 during validation). On the other hand, the highest uncertainty is seen for the Kabini dam site gauging station (forest land cover =87.88%) of the Kabini basin (p-value: 0.30 and r-value: 0.77 during calibration, and p-value: 0.20 and r-value: 0.54 during validation). Hence, F module needs to be improved to reduce the uncertainty of SHM simulations. The study highlights the importance of the uncertainty analysis in identifying the drawbacks of a hydrological model. However, further analysis needs to be done using other uncertainty analysis techniques to confirm the findings.

Key Words: SHM, Uncertainty analysis, QR technique, p-value vs r-value graph.