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Characterising multi-source uncertainties in satellite-based surrogate river discharge models

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Abstract: Satellite-based Surrogate River-discharge Model (SRM) offers a significant potential for streamflow prediction in ungauged basins through gauge-independent river discharge estimates. This study characterises multi-source error components and identifies optimal routes to enhance model reliability. The methodology employs satellite reflectance ratios as dimensionless discharge estimates, integrated with mean flow predictions derived from the Budyko relationship to ensure physical consistency. We evaluate SRM sensitivity to both surrogate river-discharge (SR) quality variations and mean flow estimation errors, establishing performance thresholds through uncertainty analysis. The analysis was conducted across 384 Australian catchments representing diverse climatic and physiographic conditions. Model performance was evaluated against observed discharge data and benchmarked against the AWRA-L hydrological model. The findings show that SRM provides reliable streamflow predictions when mean flow estimates fall within -40% to +20% of actual values, with the Budyko relationship demonstrating robust prediction across a range of parameter values (α = 2.0–4.0). SRM outperforms AWRA-L when surrogate river discharge maintains adequate correlation with actual streamflow, even under suboptimal surrogate river discharge quality conditions. Overestimation of mean flow has greater impact on performance than underestimation, and deviations beyond the optimal mean flow range cannot be compensated by improved surrogate river discharge quality. The uncertainty analysis and streamlined calibration process position SRM as a useful tool for hydrological forecasting in data-scarce regions.

Keywords: *Remote sensing, C/M ratio, Predictions in Ungauged Basins (PUB), Surrogate River discharge, Hydrologic modelling, Streamflow prediction, Budyko relationship*

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