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# Multi-site multi-variable hydrologic model development for spatially heterogeneous river basins to achieve realistic basin modelling

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Hydrologic modelling is an indispensable tool for simulation of river basin processes in water resources planning and management. Hydrologic models are used to understand dynamic interactions between climate and river basin hydrology. Model calibration, validation, parameter sensitivity and uncertainty analysis are essential prior to the application of hydrologic models. A large catchment with high spatial variability and heterogeneity can be modeled realistically when calibration is done at multiple locations, for multiple hydrologic variables like streamflow, soil moisture, sediment flow, evapotranspiration, etc. This ensures maximum utilization of field measurements of the hydrological variables, reduces the uncertainty in parameter identification and highlights the areas that need greater calibration effort. In the present study, hydrologic model simulations are run for the Mahanadi river basin in India using SWAT (Soil and Water Assessment Tool) and model calibration, uncertainty analysis, sensitivity analysis and validation are performed using SUFI-2 optimization algorithm in SWAT-CUP (SWAT Calibration and Uncertainty Programs). Entire Mahanadi basin is calibrated for several variables like streamflow, soil moisture, sediment load and evapotranspiration at various locations. The spatial heterogeneity of the catchment is taken into account in model calibration by choosing appropriate ranges of different parameters for each sub basin based on the soil types, slope classes and land use land cover present in the sub basins. When multi-site multi-variable calibration is carried out, serial calibration for individual variables and locations gives different result when compared with the simultaneous calibration for all variables and locations. In this study, a comparison of serial calibration for individual hydrologic variables and calibration sites versus simultaneous calibration for all hydrologic variables and calibration sites is made. Various performance measures like Nash-Sutcliffe efficiency (NSE), percent bias, coefficient of determination, modified NSE, etc. are used to quantify the model fit between the observed and the simulated values of various variables. The choice of performance measure affects the calibration solution, and depends on the calibration variables for which observed data is available. The performances of the fitted parameters are conditional with respect to the calibration variables and the choice of the performance measure. The present study talks about the suitability of the performance measure to different hydrologic variables like streamflow, sediment load, soil moisture, etc. The model simulation results for the Mahanadi river basin are compared with the observed values of hydrologic variables using

different performance measures for calibration and validation of the model. The results show that model performance is enhanced when it is calibrated at multiple locations, for multiple variables, by taking the spatial variability of parameters across various sub-basins into account. This study explores the suitability of different performance measures for different hydrologic variables and compares the serial and simultaneous calibration for multiple hydrologic variables at multiple locations.