EVALUATION OF HYDROLOGICAL MODELS UNDER STATIONARY AND NON-STATIONARY CONDITIONS

Climate change impacts on river runoff are unavoidable in the future. Hydrological models can be used to assess climate change impacts on river runoff in future periods. This study applies the GR4J rainfall-runoff model to explore the potential corelations between optimal parameter values and climatic characteristics in a non-stationary case and to compare the simulation performance of a stationary model and non-stationary model under historical and future conditions for the Chikaskia river near Blackwell in Oklahoma, United States.

Single and multiple linear regression analyses are used to determine regression equations for between optimal parameter values and climatic characteristics which are calculated for different 10-year time windows. The non-stationary model incorporating regression equations and the stationary model are used to simulate discharge in a sequential and reverse order to compare the performance of the regression equations. The results can be found in Table 1. The Kling-Gupta Efficiency (KGE) is higher in the sequential validation than in the reverse validation (0.66 > 0.64), therefore, the regression equations determined for the sequential order are used in the non-stationary model. When comparing the model performance of the stationary and non-stationary model and assessing climate change impact on runoff, data from the historical period of 1972-2001, future periods of 2041-2070 and 2071-2100 with two greenhouse gas emission scenarios (rcp4.5 and rcp8.4) are selected.

Results show that the stationary model performs better than the non-stationary model when simulating runoff with observed model inputs, but the non-stationary model performs better than the stationary model when simulating runoff with GCM-RCM historical inputs when compared to observed runoff (left part of Figure 1). For both models, climate change results in a larger decrease in runoff with GCM-RCM rcp4.5 inputs than an increase in runoff with GCM-RCM rcp8.5 inputs during 2045-2065, and results in a larger increase in runoff with GCM-RCM rcp8.5 inputs than a decrease in runoff with GCM-RCM rcp4.5 inputs during 2075-2095. Overall, when using GCM-RCM rcp4.5 inputs or GCM-RCM rcp8.5 inputs, the non-stationary model simulates a lower annual flow than the stationary model for 2045-2095. Based on the results of the stationary and nonstationary model simulations, climate change impacts will result in a higher annual flow when using GCM-RCM rcp8.5 projections as inputs and a lower annual flow when using GCM-RCM rcp4.5 projection as inputs.

Table 1.Calibration and validation results with KGE as objective function. Sequential order: calibration: 1948-1977, validation: 1978-2001; reverse order: calibration: 1972-2001, validation: 1948-1971.

Case	Sequential order		Reverse order	
	calibration	validation	calibration	validation
Stationary	0.81	0.79	0.82	0.76
Non-stationary	0.80	0.66	0.81	0.64

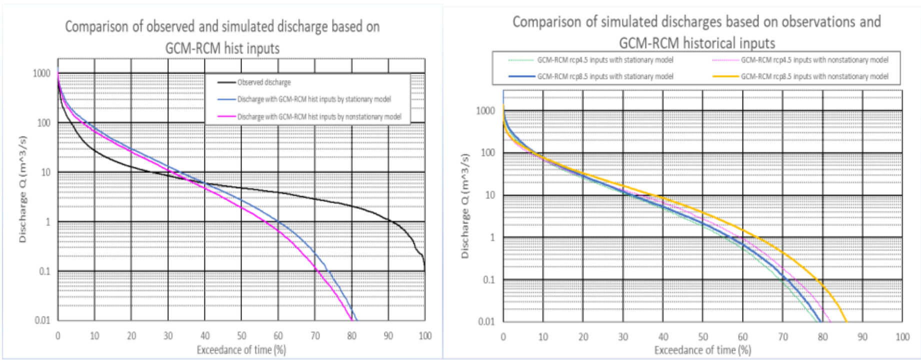

Figure 1: Flow duration curves of observed discharge and simulated discharge by both stationary and nonstationary model with GCM-RCM historical inputs for period 1976-1996 (left) and flow duration curves of simulated discharge by both stationary and nonstationary model with GCM-RCM rcp4.5 and rcp8.5 inputs for period 2045-2095 (right).

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