Assessing the performance of machine learning and conceptual hydrological models for mean and extreme streamflow prediction in the Falémé Basin at Kidira (Senegal, West Africa)
(Oral)

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ABSTRACT

Accurate prediction of river discharge, particularly extreme high and low flows, is essential for flood risk reduction, drought management, and sustainable water resources planning in West African basins. The Faleme River at Kidira, a major tributary of the Senegal River, exhibits strong hydro-climatic variability that challenges traditional rainfall–runoff modeling approaches. This study aims to evaluate and compare the performance of machine learning and conceptual hydrological models in simulating mean and extreme river flows at Kidira station. Four modeling approaches were assessed: Multilayer Perceptron (MLP), Long Short-Term Memory (LSTM), a Hybrid machine learning model (MLP-LTSM), and the conceptual GR4J rainfall–runoff model. Daily rainfall and potential evapotranspiration (PET) data from 1981 to 2024 were used as model inputs. The dataset was split into 80% for training and 20% for validation to ensure robust model evaluation. Model performance was quantified using Mean Squared Error (MSE), Root Mean Square Error (RMSE), Nash–Sutcliffe Efficiency (NSE), Kling–Gupta Efficiency (KGE), and Percent Bias (PBIAS). In addition to overall discharge simulation, models were evaluated for their ability to reproduce extreme events defined by high-flow percentiles (90th, 95th, and 99th) and low-flow percentiles (10th, 5th, and 1st). Results show that the hybrid model consistently achieved the best performance across all metrics. For mean discharge, it obtained an NSE of 0.986 and an RMSE of 37.6 m^3/s during validation, outperforming MLP (NSE = 0.984), LSTM (NSE = 0.928), and GR4J (NSE = 0.639). For high-flow extremes (90th–99th percentiles), the hybrid model maintained superior predictive skill (NSE > 0.91), with significantly lower errors compared to other models. MLP provided competitive results, while LSTM and GR4J showed reduced accuracy, particularly in reproducing peak discharges. Low-flow conditions were also better captured by the hybrid approach. These findings demonstrate the strong potential of hybrid data-driven models to simultaneously capture average hydrological behavior and extreme events in semi-arid West African basins. The results support the integration of advanced machine learning techniques into operational forecasting systems to enhance climate resilience and water resources management in the Faleme Basin.

Keywords: Faleme Basin; Kidira; rainfall–runoff modeling; extreme flows; machine learning.