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Hybrid artificial neural network, copula and hydrologic uncertainty processor for probabilistic flood forecasting

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Quantifying hydrologic uncertainty associated with the nonlinear and heteroscedastic dependence structure of multi-step-ahead deterministic flood forecasts is fundamentally challenging. A hydrologic uncertainty processor (HUP) can effectively measure hydrologic uncertainty raised in deterministic forecast models under the hypothesis that there is no input uncertainty. This study explored a HUP embedded with a copula function for configuring the probabilistic flood forecast model. The outputs of the HUP formed a posterior distribution of the process, conditional upon the deterministic forecasts. The main merit of the copula-based HUP lies in capturing the features of the nonlinear and heteroscedastic dependence structure among hydrologic variables as well as in alleviating the uncertainty encountered in operational flood forecasts. To demonstrate reliability and effectiveness of the proposed method, the copula-based HUP was implemented to generate multi-step-ahead forecasts from horizons t+1 up to t+4 at a time scale of 6-hours for a flood-induced inflow series of the Three Gorges Reservoir (TGR) in China. The back propagation neural network and the nonlinear autoregressive with exogenous inputs neural network were investigated to offer a better deterministic forecast result for further probabilistic forecasting. For comparison purpose, the meta-Gaussian HUP was also conducted. The results indicated that the proposed method not only outperformed the comparative HUP but also significantly enhanced the accuracy of probabilistic flood forecasts for the TGR inflows, where effective quantification of hydrologic uncertainty was achieved. We demonstrated that the copula-based HUP could suitably extract the complex nonlinear and heteroscedastic dependence structure relating to the outputs of the deterministic forecast model. Consequently, hydrologic uncertainty could be alleviated and model reliability as well as forecast accuracy for future horizons could be significantly improved.

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