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Constructing hybrid forecasting models to exhibit the nonlinear effect of climate change on runoff

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It is of profound significance to improve the forecasting accuracy of runoff using reasonable methods for scientific formulation of water resources management strategies. Currently, many scholars have paid much attention to the hybrid forecasting simulation of runoff variation, while it is rare to construct an ensemble prediction model based on the nonlinear change process of runoff.

In this study, the freezing level height and summer runoff in the Hotan River are employed to analyze the nonlinear relationships of climatic and hydrological factors at different time scales using three nonlinear decomposition methods, which are wavelet analysis, ensemble empirical mode decomposition and extreme-point symmetric mode decomposition (ESMD). Combined with linear regression and back-propagation artificial neural network (BPANN), six hybrid forecasting models are established. The decomposition results of three nonlinear methods are compared, which indicate that ESMD shows better performance than the other two methods. Among the six forecasting models, ESMD-BPANN shows the highest accuracy according to the indicators of Cronbach's α, $\hat{\pi}$(rel) value, Akaike information criterion, etc. The ESMD-BPANN model is thus selected for forecasting.

Our forecasts indicate that the runoff will have fluctuations, and a trend for a slight increase from 2014 to 2030, at a rate of $0.124\times10\hat{8}$ m^3/year. This model predicts low runoff in 2014, 2017, 2024, and 2028, and high runoff in 2018, 2023, 2029, and 2030. This demonstrates that the inter-annual variations of runoff will be large and unstable. Therefore, hydrologists must devote further attention to variations of runoff so they can formulate strategies for improved management of water resources.