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# Predicting longer lead droughts with Bayesian model averaging ensemble vine copula (BMAViC) model

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In the face of global anthropogenic climate warming, particularly since the 1990s, the world has witnessed numerous extreme weather and climate events (e.g., droughts, heatwaves, and extreme precipitation), leading to economic losses and ecosystem degradation. In particular, drought prediction lies at the core of overall drought risk management and is critical for food security, early warning, and drought preparedness and mitigation. However, drought prediction models generally focus on shorter lead times (1–3-months) as their performance drastically declines at longer lead times (> 3 months). The vine copula can decompose complex non-linear, multi-variates into pairwise variables via bivariate copula forms which can well depict the diverse dependencies among variables (note that a vine copula possesses numerous vine structures, especially under higher-dimensional situations), while the Bayesian model averaging (BMA) can assign different weights to each ensemble member which depends on the explanatory power of the member itself for the specified objective. We therefore developed a new drought prediction model utilizing the BMA coupled with vine copula, called the Bayesian Model Averaging ensemble Vine Copula (BMAViC) model. Two drought types, i.e., hydrological drought (characterized by the standardized streamflow index (SSFI)) and agricultural drought (depicted by standardized soil moisture index (SSI)), were predicted with different lead times based on the BMAViC model under four-dimensional situations. Our model first was applied to predict the hydrological drought with the 1–3-month lead times for five hydrological stations (i.e., Tangnaihai, Minhe, Hongqi, Zheqiao, and Xiangtang) in the Upper Yellow River basin, in which previous meteorological drought, antecedent evaporative drought, and preceding hydrological drought were selected as three predictors. The BMAViC model showed robust skills during calibration and validation periods for 1–3-month lead hydrological drought predictions. In comparison with the meta-Gaussian model (reference model), the skills of the proposed model were relatively stable and superior under diverse lead times. Good performances under the 1–3-month lead times strongly implied that the BMAViC model yielded robust and accurate hydrological drought predictions. Considering the previous meteorological drought, antecedent hot condition, and agricultural drought persistence as three predictors, our proposed BMAViC model was further leveraged to predict the agricultural drought in the summer season over China with the 1–6-month lead times. Compared with optimal vine copula (OViC), average vine copula (AViC), and persistence-based models, the BMAViC model performed better for the 1–6-month lead agricultural drought predictions. Besides, the BMAViC model yielded a good prediction ability for extreme droughts. These findings enhance our confidence in seasonal drought prediction and help us understand drought dynamics in future months.