A hidden Markov model for long term drought forecasting in South Korea

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ABSTRACT

Drought events usually evolve slowly in time and their impacts generally span a long period of time. This indicates that the sequence of drought is not completely random. The Hidden Markov Model (HMM) is a probabilistic model used to represent dependences between invisible hidden states which finally result in observations. Drought characteristics are dependent on the underlying generating mechanism, which can be well modelled by the HMM. This study employed a HMM with Gaussian emissions to fit the Standardized Precipitation Index (SPI) series and make multi-step prediction to check the drought characteristics in the future. To estimate the parameters of the HMM, we employed a Bayesian model computed via Markov Chain Monte Carlo (MCMC). Since the true number of hidden states is unknown, we fit the model with varying number of hidden states and used reversible jump to allow for transdimensional moves between models with different numbers of states. We applied the HMM to several stations SPI data in South Korea. The monthly SPI data from January 1973 to December 2012 was divided into two parts, the first 30-year SPI data (January 1973 to December 2002) was used for model calibration and the last 10-year SPI data (January 2003 to December 2012) for model validation. All the SPI data was preprocessed through the wavelet denoising and applied as the visible output in the HMM. Different lead time (T= 1, 3, 6, 12 months) forecasting performances were compared with conventional forecasting techniques (e.g., ANN and ARMA). Based on statistical evaluation performance, the HMM exhibited significant preferable results compared to conventional models with much larger forecasting skill score (about 0.3-0.6) and lower Root Mean Square Error (RMSE) values (about 0.5-0.9).

Keywords: Drought, Hidden Markov Model, Forecasting, Standardized Precipitation Index

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