A probabilistic framework for drought forecasting using hidden Markov models aggregated with the RCP8.5 projection

Si Chen*, Hyun-Han Kwon**, Tae-Woong Kim***

Abstract

Forecasting future drought events in a region plays a major role in water management and risk assessment of drought occurrences. The creeping characteristics of drought make it possible to mitigate drought's effects with accurate forecasting models. Drought forecasts are inevitably plagued by uncertainties, making it necessary to derive forecasts in a probabilistic framework. In this study, a new probabilistic scheme is proposed to forecast droughts, in which a discrete-time finite state-space hidden Markov model (HMM) is used aggregated with the Representative Concentration Pathway 8.5 (RCP) precipitation projection (HMM-RCP). The 3-month standardized precipitation index (SPI) is employed to assess the drought severity over the selected five stations in South Kore. A reversible jump Markov chain Monte Carlo algorithm is used for inference on the model parameters which includes several hidden states and the state specific parameters. We perform an RCP precipitation projection transformed SPI (RCP-SPI) weight-corrected post-processing for the HMM-based drought forecasting to derive a probabilistic forecast that considers uncertainties. Results showed that the HMM-RCP forecast mean values, as measured by forecasting skill scores, are much more accurate than those from conventional models and a climatology reference model at various lead times over the study sites. In addition, the probabilistic forecast verification technique, which includes the ranked probability skill score and the relative operating characteristic, is performed on the proposed model to check the performance. It is found that the HMM-RCP provides a probabilistic forecast with satisfactory evaluation for different drought severity categories, even with a long lead time. The overall results indicate that the proposed HMM-RCP shows a powerful skill for probabilistic drought forecasting.

Keywords : Drought forecasting, Hidden Markov model, RCP climate scenario

Acknowledgement: This research was supported by a grant (14AWMP-B082564-01) from Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

* PhD student, Dept. of Civil and Environmental Engineering, Hanyang University · E-mail : kathryn123@hanyang.ac.kr

** Member, Dept. of Civil Engineering, Chonbuk National University · E-mail : hkwon@jbnu.ac.kr

*** Member, Dept. of Civil and Environmental Engineering, Hanyang University (Corresponding Author, E-mail : twkim72@hanyang.ac.kr)