SPI-Based Hybrid Wavelet–ANN Models for Drought Forecasting in north Tunisia

R. Ouachani[1], Z. Bargaoui[2]
[1] *Higher Institute of Transport and Logistics of Sousse - Sousse University*
Cité Erriadh, BP 247, 4023, Sousse – Tunisia
Email: rim.ouachani@istls.u-sousse.tn
[2]*National Engineering School of Tunis - El Manar University*

ABSTRACT

Severe drought events in recent decades, along with the potential increase of drought frequency and severity due to climate change, have highlighted the urgent need for arid and semi-arid countries to establish effective early-warning of drought hazards systems that incorporate accurate drought monitoring, reliable drought forecasting, and effective information dissemination. Moreover, drought forecasting is necessary for water resources, agriculture, food security and eco-environmental management. Recently, stand-alone machine learning techniques such as artificial neural networks (ANN) were used to forecast climate data. However, lately, hybrid models have been introduced, which are created by integrating different time series decomposition techniques into standalone models, since the accuracy of stand-alone models used in the drought prediction being low particularly for mid-term and long-term drought predictions. This study assessed then the capability of the hybrid neural network model to forecast meteorological drought based on the standardized precipitation index (SPI). Model input data pre-processing with wavelet multiresolution decomposition (MWD) for improving the performance of the models was carried out apriori. First, MWD is used to decompose SPI3 data time series into their sub-bands. Then the ANN ensemble model allowed to identify the statistical links between the decomposed inputs and the decomposed outputs according to temporal scales and to predict each SPI3 decomposition. Ensemble drought forecasts were carried out. SPI3 time series were used to achieve 1, 3 and 6-month lead time predictions. For operational forecasting, the forecasts obtained from the decompositions are summed to represent the true precipitation forecast value. The SPI was computed at 3 months time scale (SPI3) from 70 years of data for several rainfall stations located in the Medjerda basin located in northern Tunisia witch is a semi-arid region. The results reveal that the hybrid model yielded acceptable accuracy for SPI3 forecasting for long-term forecasting in terms of coefficient of determination (R2) and Nash-Sutcliffe efficiency (NSE). Considering the Medjerda region, the hybrid wavelet model outperformed the stand-alone model for not only 1-month lead time with R2 exceeding 0.8 in the majority of rainfall stations. Thus, the wavelet hybrid model is recommended as a robust model for drought forecasting.

Keywords: Drought, forecasting, SPI, Hybrid models, multiresolution wavelet decomposition, ANN