ABSTRACT

Modelling suspended sediment load (SSL) from rivers is a complex problem in river basin management. This chapter presents hybrid framework multivariate empirical mode decomposition (MEMD) and stepwise linear regression (SLR) for estimation of SSL from riverflows demonstrated to a case study in Mahanadi River Basin, India. The method involves two major steps: first, the multivariate dataset comprising SSL of current time along with lagged inputs of streamflow and SSL are decomposed into different modes using MEMD; then, the obtained modes are estimated independently by SLR fitting engaging the statistically significant inputs at respective time scales. The sum of the predicted modes gives the desired SSL. The effectiveness of the presented method is evaluated for five models by considering different combinations of inputs, and their performance is compared with traditional multiple linear regression (MLR) and model tree (MT) models. The performance statistics of models showed that for estimation of SSL, the MEMD-SLR approach performs better than MLR and MT models.

INTRODUCTION

Modelling suspended sediment load (SSL) from rivers is a complex problem in hydrology, which plays a significant role in river basin management, assessment of risk, operation and monitoring of hydraulic structures like dams and canals. For modelling SSL, time series analysis is used as a simple and popular approach based on the inherent assumption that the lagged values of input fairly represents the factors...
deciding the fate of the magnitude of SSL at the present time step. Like many other predictive modelling problems in hydrology, numerous data driven techniques and their hybrid variants were proposed for prediction of SSL in recent past (Kisi, Yuksel, & Dogan, 2008; Rajaee, T., Mirbagheri, Zounemat-Kermani, & Nourani, 2009; Senthil Kumar, Ojha, Goyal, Singh, & Swamee, 2011; Lafdani, Nia, & Ahmadi, 2013; Rajaee 2011; Haji, Mirbagheri, Javid, Khezr, & Najafpour, 2014; Nourani & Andalib, 2015; Zounemat-Kermani, Kisi, Adamowski, Ramezani-Charmahineh, 2016). The wavelet transforms were adopted as the decomposition technique for improving the predictability efforts of hydrologic problems by many researchers in the past (Nourani, & Andalib, 2014). The selection of appropriate mother wavelet function and fixation of appropriate number of decomposition levels are two key issues associated with wavelet based hybrid models and the guidelines proposed by past researchers seem to be lacking scientific reasoning, less quantitative nature and difficult to implement in practice (Sang, Singh, Sun, Che, Liu, & Yang, 2016). Empirical Mode Decomposition (EMD) proposed by Huang et al. (1998) is a data adaptive decomposition technique, which can solve the above stated issues related to wavelet transforms to a certain extent, and also it was applied for a large number of prediction problems in hydrology in recent past (Napolitano, Serinaldi, & See, 2011; Karthikeyan & Nagesh Kumar, 2013; Huang, Cheng, Huang, & Chen, 2014; Zhang, Peng, Zhang, & Wang, 2015; Zhu, Zhou, Ye, & Meng, 2016). But, in most of the EMD based hybrid models, first the decomposition of the concerned time series is performed, followed by the predictions of subseries considering the appropriate lagged values of subseries as inputs. Then, summation of the predicted series at different time scale will provide the variable of concern at the observation scale (such as daily or monthly), which can be referred as an ‘additive modelling’ strategy. In such studies a ‘pure’ time series approach is followed which accounts only the variable of concern (with appropriate time lags) in the modelling process. Few studies followed cause-effect approach, in which the causal variables such as rainfall is also considered in modelling streamflow (Wang, Xu, Cha, & Chen, 2013; Zhu, Zhou, Ye, & Meng, 2016). But, in such studies, the decomposed components are directly used as inputs without following the ‘additive modelling’ strategy, i.e., such studies didn’t consider the appropriate inputs at different time scales. Infact in multiscale hydrologic modelling, it is important to consider appropriate models for different sub-series (at different time scale). While adopting such a modelling strategy, the modeller cannot ensure the same number of component for all the variables of concern (as it may depend on the characteristics of the time series), which may pose difficulty in modelling. This problem, so called ‘mode misalignment’ constrains the modeller to proceed with an EMD based hybrid modelling with multiple inputs (Huang, Su, Kareem, & Liao, 2016). In this context, employing the use of Multivariate Empirical Mode Decomposition (MEMD) for time series decomposition may be an alternative, as it can ensure same number of modes for all of the considered time series by identifying the common scales in them. Also it is believed that identifying the most appropriate predictors and excluding the less contributing (less significant) components at different time scales, may improve the accuracy of hydrologic predictions considerably, owing to the multiscale character of the involved time series. Investigating in this direction, this chapter presents an innovative hybrid modelling framework involving MEMD and Stepwise Linear Regression (SLR) for daily SSL prediction. This chapter (1) proposes a method for suspended sediment load prediction based on MEMD and SLR; (2) compare the performance of MEMD-SLR model results with that by M5 model tree (MT) and multiple linear regression (MLR).