A Nonlinear Dynamical Systems based Model for Stochastic Simulation of Streamflow

Solomon Erkyihun[1,2], Balaji Rajagopalan[1,3] and Edith Zagona[1.2]
[1]Civil, Environmental, and Architectural Engineering, University of Colorado, Boulder, CO
[2]CADSWES, University of Colorado, Boulder, CO
[3]CIRES, University of Colorado, Boulder

Abstract. Traditional time series methods model the evolution of the underlying process as a linear or nonlinear function of the autocorrelation. These methods capture the distributional statistics but are incapable of providing insights into the dynamics of the process, the potential regimes, and predictability. We propose using nonlinear dynamical systems based time series methods to understand and recover the underlying dynamics and simulate. This work develops a nonlinear dynamical model for stochastic simulation of streamflows in the Colorado River Basin which complements the wavelet spectrum based WARMA method. In this model, first a wavelet spectral analysis is employed on the Lees Ferry naturalized flow series to isolate dominant orthogonal periodic bands – this step is also common to the WARMA method. The periodic bands are added denoting the 'signal' component of the time series and the residual being the 'noise' component. Next, the underlying nonlinear dynamics of this combined band time series is recovered. For this the univariate time series is embedded in a d-dimensional space with an appropriate lag t to recover the state space in which the dynamics unfolds. Predictability can be assessed by quantifying the divergence of trajectories in the state space corresponding to various time points, as Lyapunov exponents. The dynamics in conjunction with a K-nearest neighbor time resampling is used to simulate the combined band, to which the noise component is added to simulate the time series. We demonstrate this method by applying it to paleo and historic annual flow at Lees Ferry. We identify interesting dynamics of the signal in the flow series and epochal behavior of predictability. These will be of immense use for water resources planning and management.