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Data-driven approach to Great Lakes water levels forecasting

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Echo state networks (ESNs) have recently emerged as effective methods for complex system modeling including dynamic time series forecasting. However their performance on geophysical time series modeling remains largely unexplored. The potential of ESNs is investigated for long-term prediction of Lake Erie and Lake Ontario water levels. Mean monthly water levels from 1918 to 2005 are used for model set-up to predict future water levels up to 10 months ahead. ESNs are new recurrent neural network structures, therefore a logical choice for model comparison is the conventional Elman type recurrent neural network (RNN). A Bayesian neural network (BNN) is also included given that it has been recently shown as a very competitive method when compared with the RNN for long-term hydrological time series forecasting. The forecast results indicate that, overall, the ESNs obtained the best performance whatever the forecast range. The comparative forecast results also indicate that the RNN appears more effective for lake water levels forecasting than BNN. In addition to outperforming the two other models, the ESNs have two major advantages, they are much easier to train than RNN and BNN, and they do not require a functional mapping in the hidden layer. A particularly interesting feature of the ESNs is that its hidden layer is entirely driven by the inputs and the network's internal dynamics generated by random and sparse connections.