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Wavelet Enhanced LSTM for Accurate Streamflow Modeling Addressing Nonlinearity and Nonstationarity in Hydrological Data

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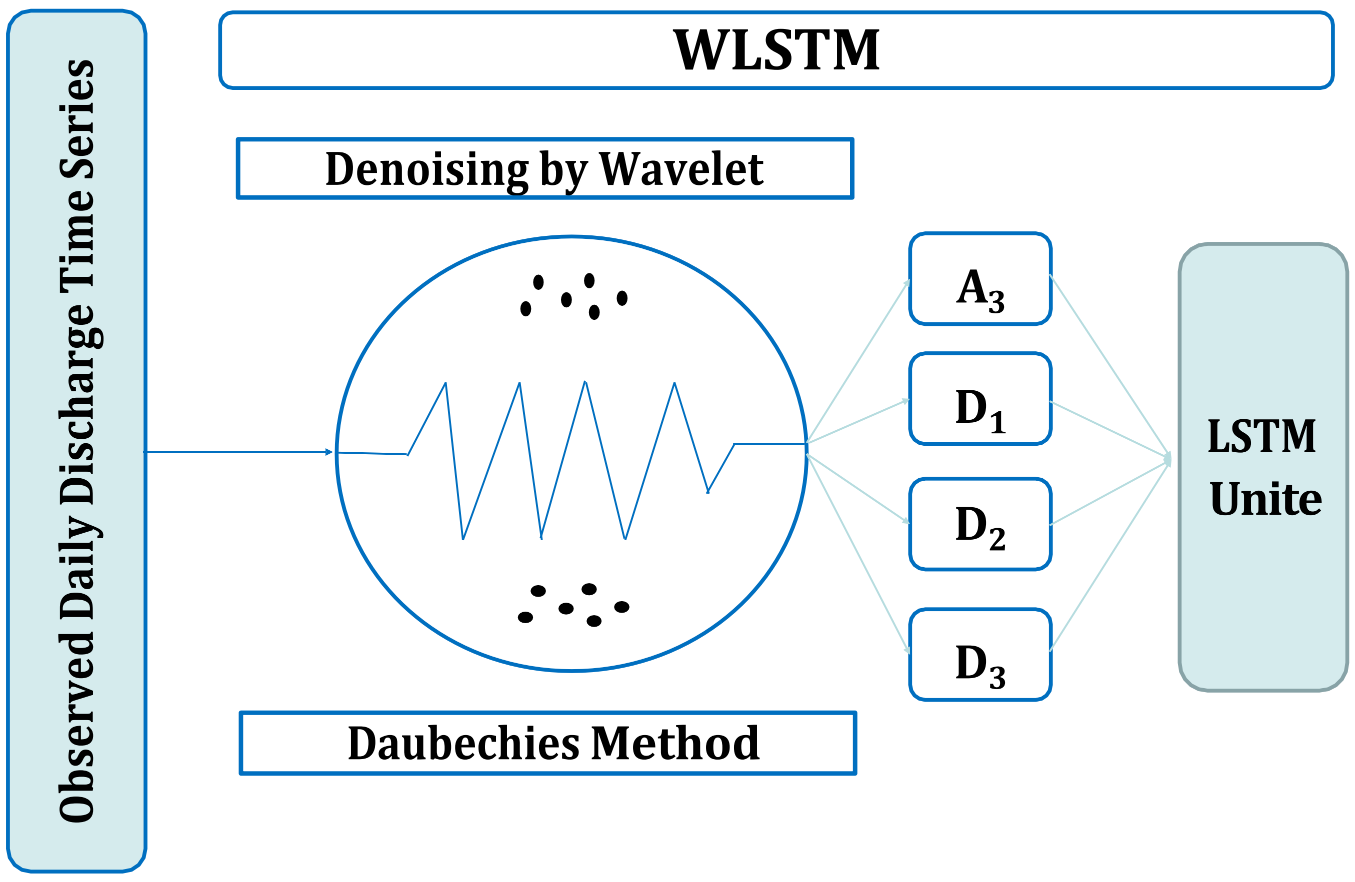
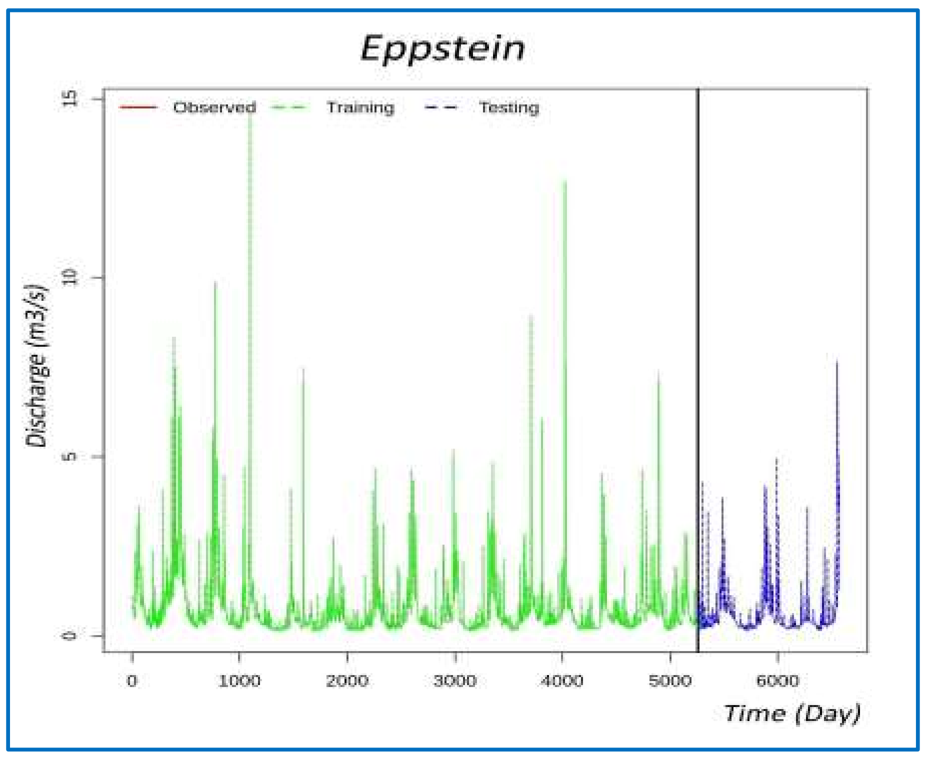
Introduction

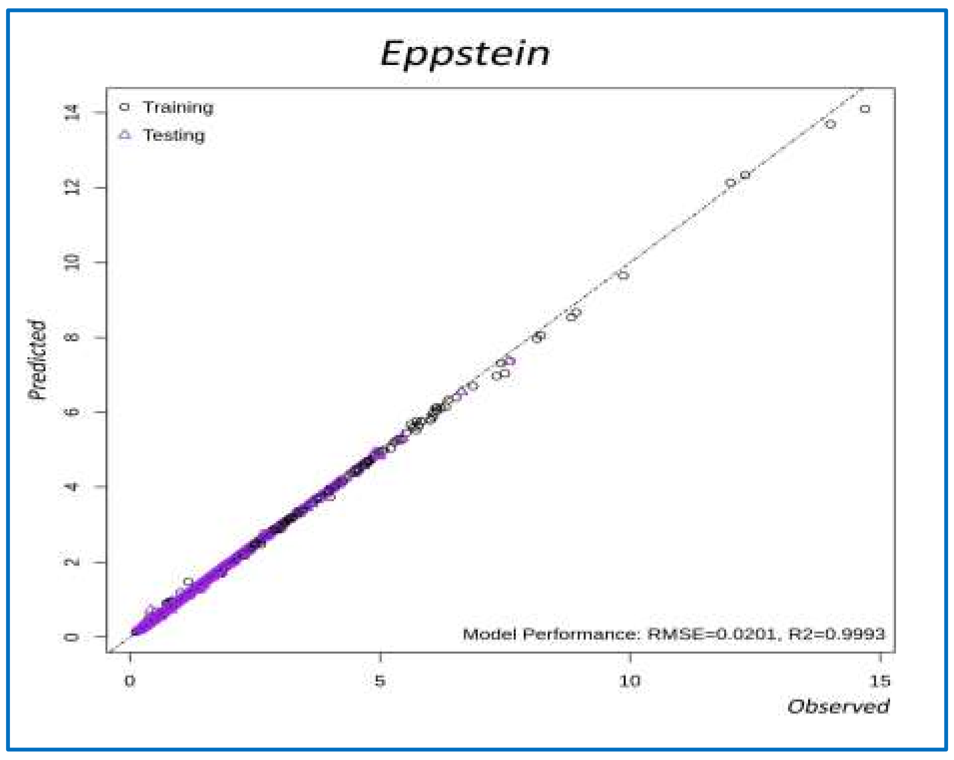
Hydrological time series modeling plays a critical role in flood forecasting and understanding the streamflow dynamics. In this study, we developed a novel hybrid model, **WLSTM (Wavelet-based Long Short-Term Memory)**, integrating wavelet transform with LSTM to enhance discharge prediction by reducing overfitting, addressing noise, and improving signal quality. Our results demonstrate a significant improvement in predictive accuracy, with **66% reduction in RMSE** compared to baseline models. The paper detailing this research has been submitted and is currently under review.

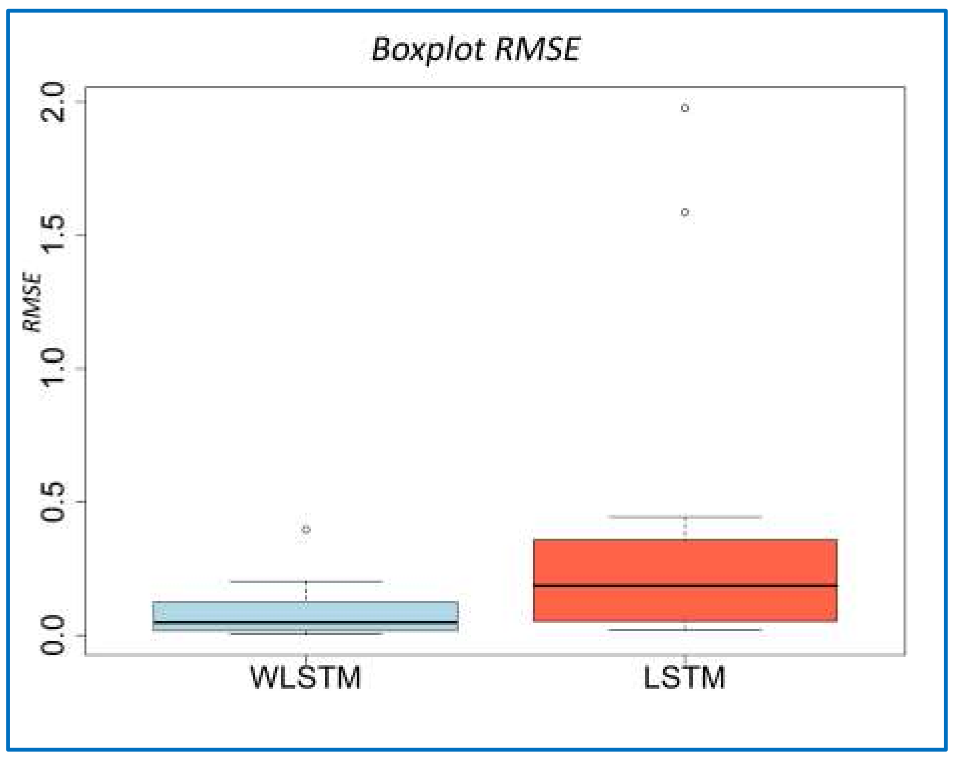


Conclusion

WLSTM enhances discharge prediction by addressing noise and improving accuracy compared to traditional LSTM models. Its ability to minimize large errors and capture streamflow nonlinearity demonstrates its potential for flood forecasting. Our analysis reveals that WLSTM's performance improves with increasing nonlinearity, highlighting its potential for complex hydrological time series with chaotic behavior. WLSTM not only demonstrates robust performance in capturing complex hydrological patterns but also offers a reliable framework for accurate and consistent discharge predictions.







Upcoming Directions

A
- Develop a Fuzzy Logic-based hybrid model, optimizing adaptability in diverse hydrological scenarios.

B
- Compare predictive performance of WLSTM with and without Fuzzy Logic across.

C
- Explore the application of the hybrid WLSTM-Fuzzy Logic model to real-time flood forecasting systems

By incorporating Fuzzy Logic, we expect to enhance model robustness and provide more reliable discharge predictions for flood management and water resource planning, due to its ability to handle uncertainty and capture complex, nonlinear relationships in hydrological processes, ensuring system resilience.