Daily Streamflow Forecasting in the Mahanadi River Basin using a Novel Deep Learning-based Model

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Introduction

- Flood is one of the widespread natural disasters posing a threat to the life and property of millions of people worldwide (Lechowska 2018).
- In operational flood forecasting, rainfall-runoff simulation is a complex non-linear hydrological process that is influenced by various factors, such as the catchment's geography, climate and underlying surface, and human activities (Feng et al. 2021).
- Few improvements to the classic LSTM modelling framework have been incorporated to date (Kao et al. 2020).

Study Area and Data used

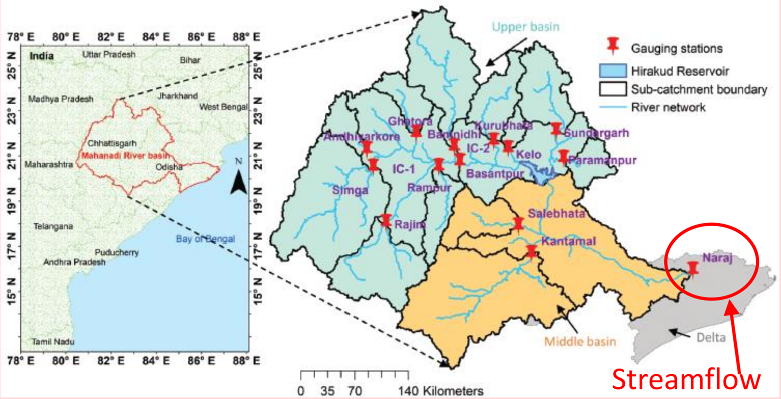


Fig. Mahananadi River basin

- Geographical area = 141,589 km^2
- Average annual rainfall = 1500 mm
- Tropical monsoon (June-September) region
- Suffered several devastating floods (in 2001, 2003, 2006, 2008, 2011 and 2014)
- Input data to Smooth-LSTM: Time-lagged discharges at Mundali gauging site (immediately upstream of Naraj)

Methodology

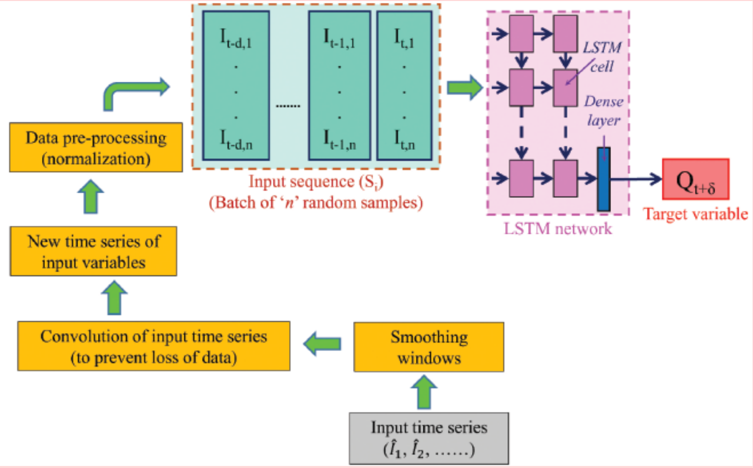


Fig. Smooth-LSTM modelling framework for daily streamflow forecasting

Conclusions

- The LSTM network is able to learn better at smaller network and batch sizes.
- The Smooth-LSTM showed consistency in discharge prediction up to 5-days lead-time.
- The Smooth-LSTM has less sensitivity to redundant information and noise in the input dataset.
- The Smooth-LSTM is robust in daily streamflow forecasting characterized with the narrowest uncertainty bands.

References

Feng, R., *et al.*, 2021. Enhanced long short-term memory model for runoff prediction. *Journal of Hydrologic Engineering*, 26 (2), 04020063.

Kao, I.F., *et al.*, 2020. Exploring a long short-term memory based encoder-decoder framework for multi-step-ahead flood forecasting. *Journal of Hydrology*, 583, 124631.

Lechowska, E., 2018. What determines flood risk perception? A review of factors of flood risk perception and relations between its basic elements. *Natural Hazards*, 94 (3), 1341–1366.

Results

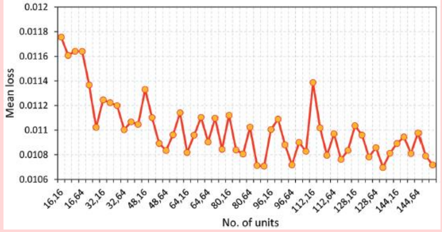


Fig. Effect of LSTM units on the learning efficiency of the LSTM network

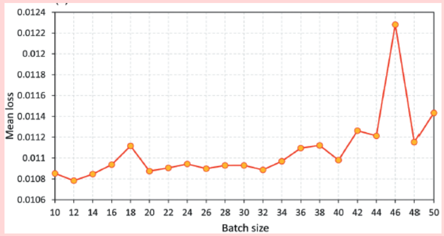
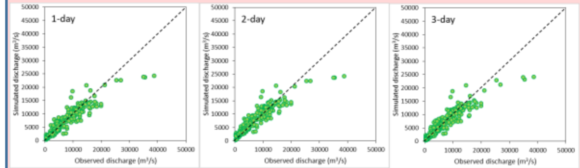
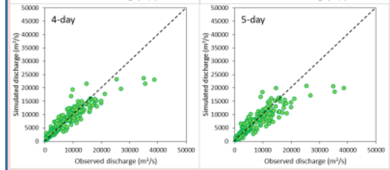


Fig. Effect of batch size on the learning efficiency of the LSTM network





Lead-time (days)	NSE (-)
1	0.87
2	0.86
3	0.87
4	0.87
5	0.82

Comparison of observed vs forecasted streamflows at 1-5 days lead-time

Thus, Smooth-LSTM shows satisfactory performance in daily streamflow forecasting

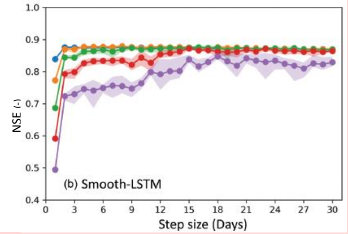


Fig. Sensitivity of the Smooth-LSTM model with input time-lags

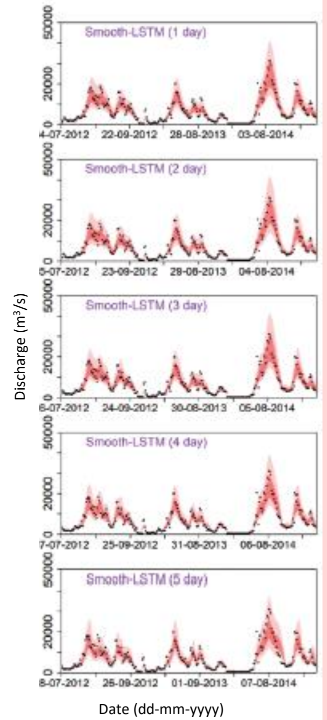


Fig. Quantile Regression-based uncertainty assessment

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