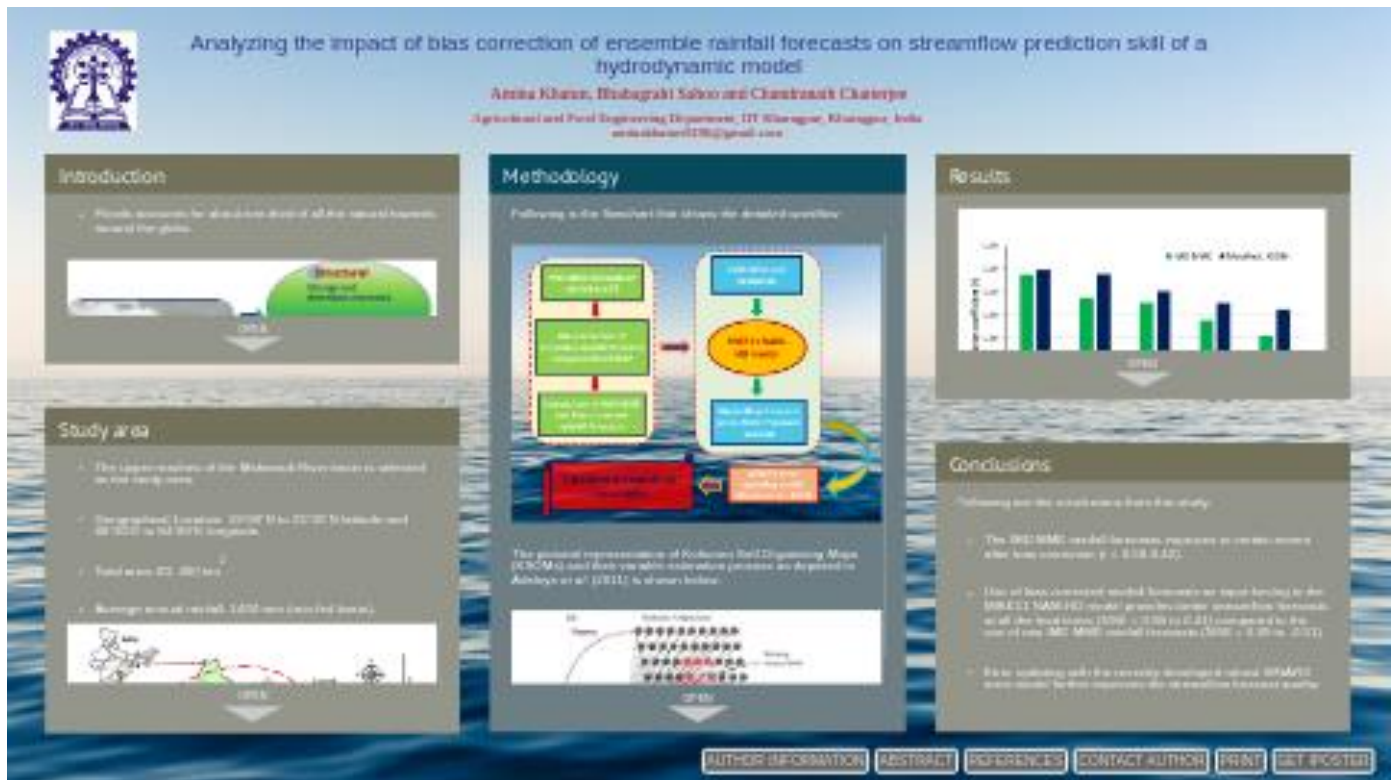


Analyzing the impact of bias correction of ensemble rainfall forecasts on streamflow prediction skill of a hydrodynamic model



Amina Khatun, Bhabagrahi Sahoo and Chandranath Chatterjee

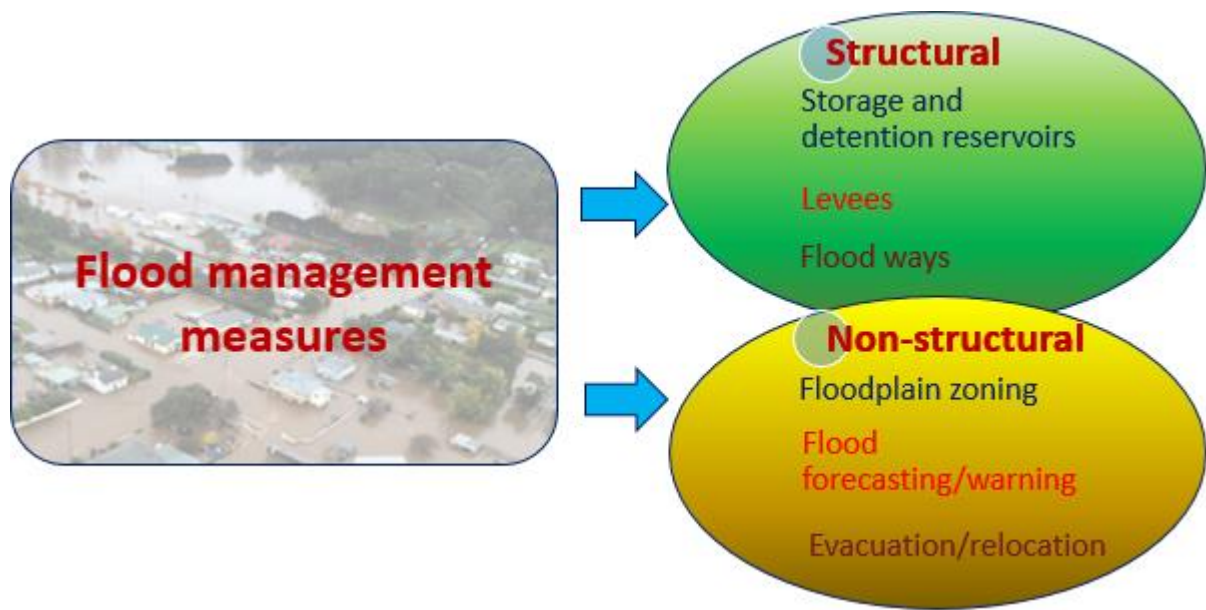
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PRESENTED AT:



INTRODUCTION

- Floods accounts for about one-third of all the natural hazards around the globe.



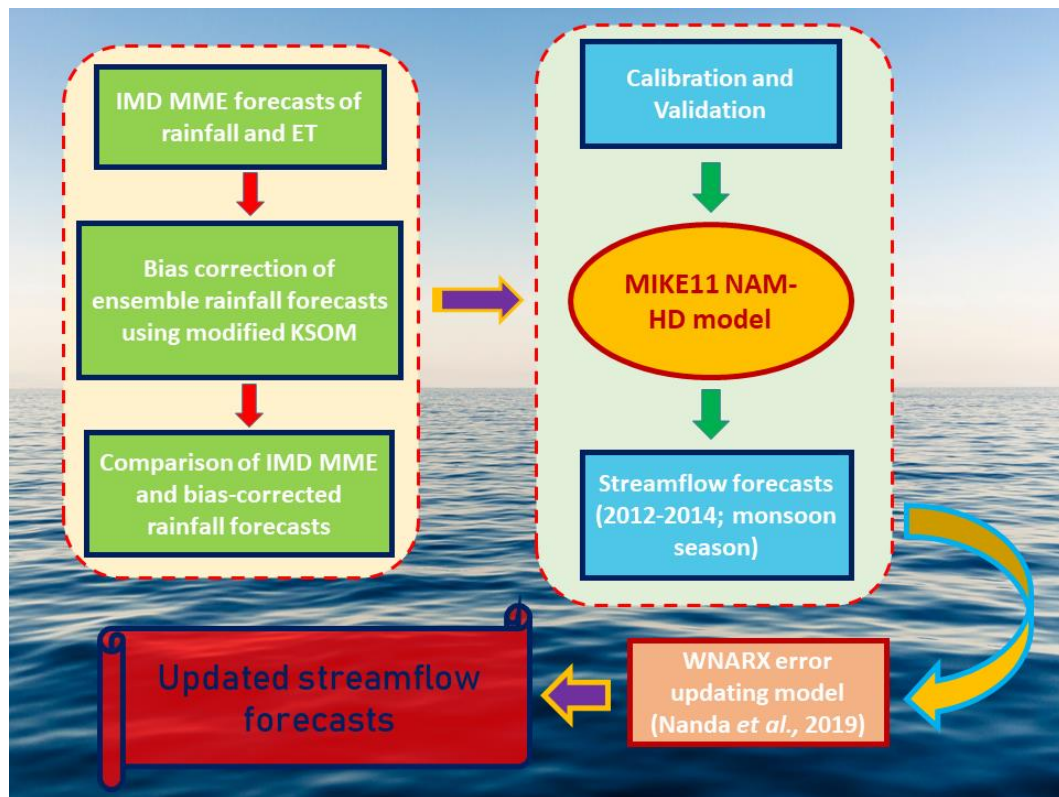
- Reliable inflow forecasts into a reservoir with a sufficient lead-time could serve for effective flood management.
- Regardless of the flexibility of KSOM, very few applications are studied in the field of hydrological modeling (Nanda *et al.*, 2017).
- As a state-of-the-art, the MIKE11 model has been applied across many river basins worldwide.
- The data-driven models, though does not have a clear physical significance of the elements of hydrologic cycle, have ease of calibration to result in effective flow forecasts.

STUDY AREA

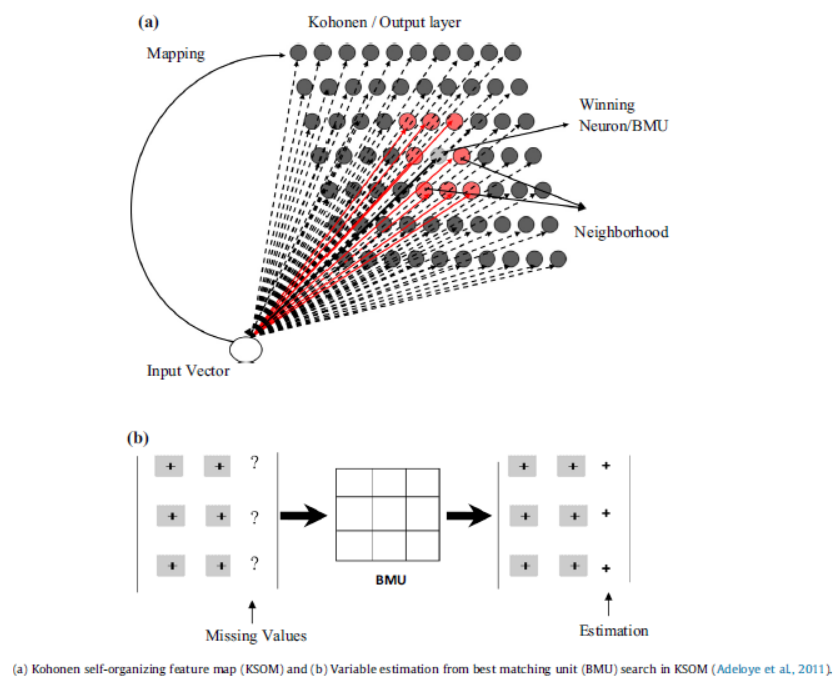
- The upper reaches of the Mahanadi River basin is selected as the study area.
- Geographical Location: 19°90'N to 23°35'N latitude and 80°30'E to 84°80'E longitude.
- Total area: 83, 400 km².
- Average annual rainfall: 1400 mm (rain-fed basin).

METHODOLOGY

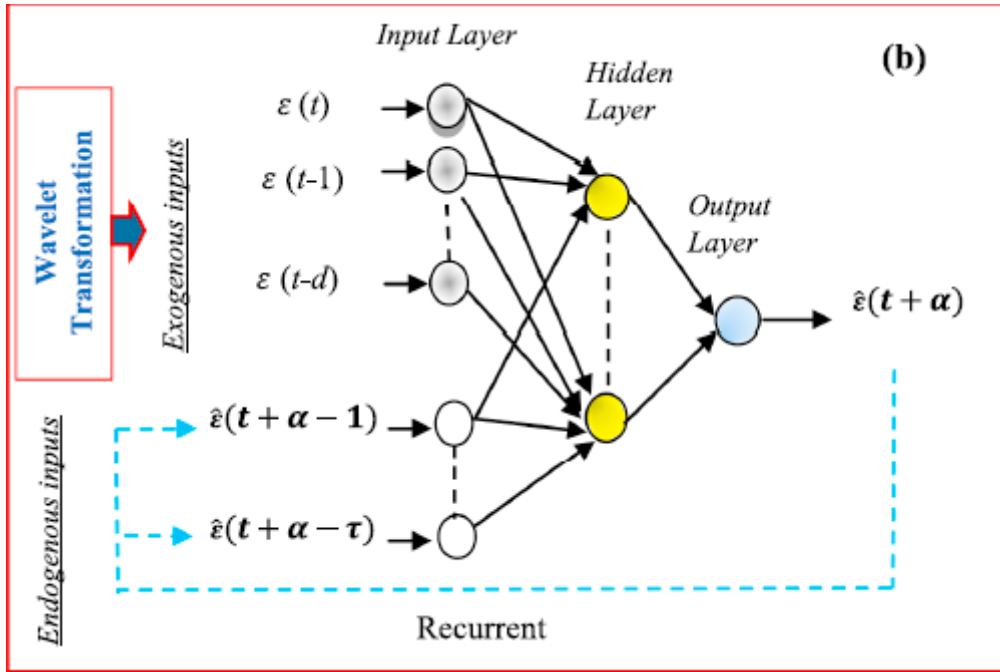
Following is the flowchart that shows the detailed workflow:



The pictorial representation of Kohonen Self-Organising Maps (KSOMs) and their variable estimation process as depicted in Adeloje *et al.* (2011) is shown below:



- However, here the enhanced KSOM, in which the map units is a function of coefficient of variation (CV, %) is used (Nanda *et al.*, 2017).
- The Wavelet-based Non-linear Auto-Regressive with eXogenous inputs (WNARX) error updating model developed by Nanda *et al.* (2019) is shown below:



Where, ε = streamflow prediction error

t = time of forecast

d = effective lag time for exogenous inputs

ζ = effective lag time for endogenous inputs

α = lead time

RESULTS

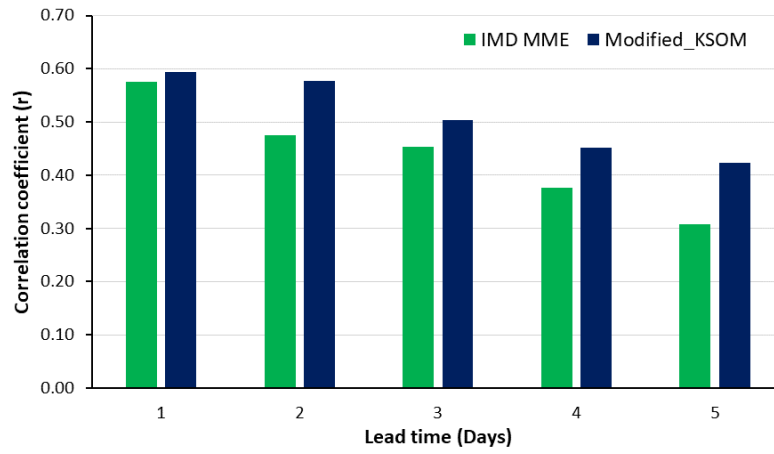


Fig. Correlation coefficient of IMD MME and the bias-corrected rainfall forecasts with observed rainfall.

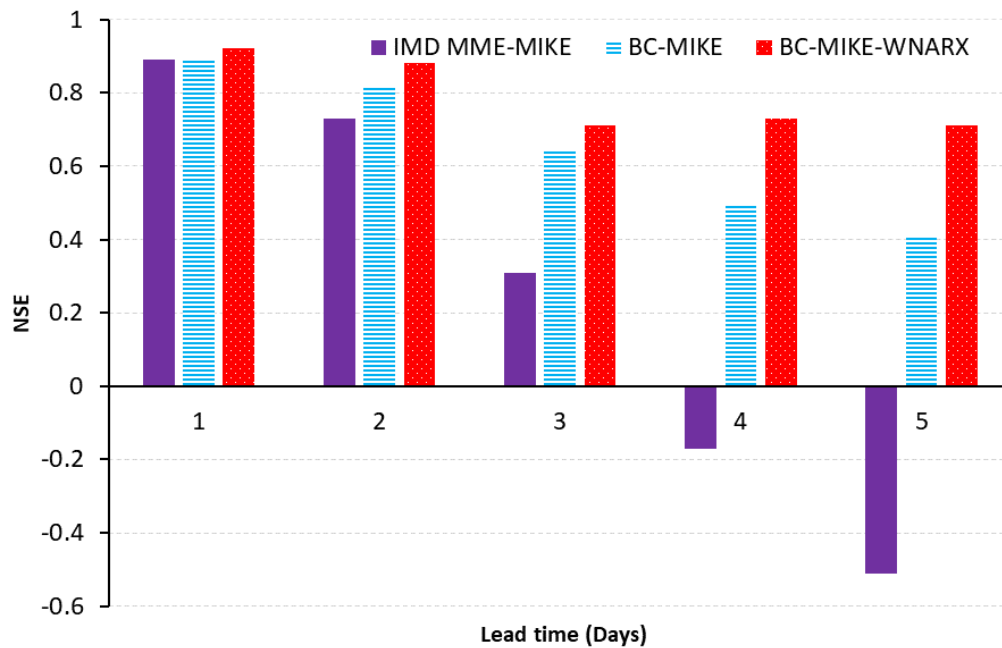


Fig. NSE of streamflow prediction by (a) MIKE11 NAM-HD model using IMD MME rainfall data (IMD MME-MIKE), (b) MIKE11 NAM-HD model using bias-corrected IMD MME rainfall data (BC-MIKE), and (c) MIKE11 NAM-HD model using bias-corrected IMD MME rainfall data and error updating using WNARX error model (BC-MIKE-WNARX).

CONCLUSIONS

Following are the conclusions from this study:

- The IMD MME rainfall forecasts improves to certain extent after bias correction ($r = 0.59-0.42$).
- Use of bias corrected rainfall forecasts as input forcing to the MIKE11 NAM-HD model provides better streamflow forecasts at all the lead times ($NSE = 0.89$ to 0.41) compared to the use of raw IMD MME rainfall forecasts ($NSE = 0.89$ to -0.51).
- Error updating with the recently developed robust WNARX error model further improves the streamflow forecast quality to an acceptable range ($NSE = 0.92-0.71$) up to 5-days lead time.

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ABSTRACT

Use of ensemble rainfall forecasts has gained popularity in providing detailed uncertainty information and improving hydrologic prediction skill. India Meteorological Department (IMD) provides medium-range multi-model ensemble (MME) forecasts for all over India with 1- to 5-day lead time. In this study, we bias correct the IMD MME rainfall forecasts using a modified version of Kohonen Self-Organizing Maps (KSOM) and analyse the effect of bias correction on the streamflow prediction skill of MIKE11 NAM Hydrodynamic (HD) model for the years 2012-2014. We have selected the upper region of the Mahanadi River basin as the test bed. The results indicate improvement of rainfall forecasts after bias correction. Subsequently, use of bias corrected rainfall forecasts as input forcing to the MIKE 11 HD model provides better streamflow forecasts at all the lead times (Nash Sutcliffe Efficiency, NSE ranging from 0.89 to 0.41) compared to the use of raw forecasts (NSE ranging from 0.89 to -0.51). To further improve the streamflow forecasts, we have applied the recently developed robust wavelet-based non-linear autoregressive with exogenous inputs dynamic neural network model, WNARX. This post-processing operation tends to improve the streamflow forecast quality to an acceptable range (NSE = 0.92-0.71). The results encourage us to conclude that the IMD MME forecasts has great potential to improve streamflow prediction skill of a hydrodynamic model.

REFERENCES

Adeloye, A. J., Rustum, R., & Kariyama, I. D. (2011). Kohonen self-organizing map estimator for the reference crop evapotranspiration. *Water Resources Research*, 47(8).

Jena, P. P., Chatterjee, C., Pradhan, G., & Mishra, A. (2014). Are recent frequent high floods in Mahanadi basin in eastern India due to increase in extreme rainfalls?. *Journal of Hydrology*, 517, 847-862.

Nanda, T., Sahoo, B., & Chatterjee, C. (2017). Enhancing the applicability of Kohonen Self-Organizing Map (KSOM) estimator for gap-filling in hydrometeorological time series data. *Journal of Hydrology*, 549, 133-147.

Nanda, T., Sahoo, B., & Chatterjee, C. (2019). Enhancing real-time streamflow forecasts with wavelet-neural network based error-updating schemes and ECMWF meteorological predictions in Variable Infiltration Capacity model. *Journal of Hydrology*, 575, 890-910.