Abstract

- We examine the utility of a modeling framework with requisite simplicity – to paraphrase Einstein 'simple, but not simpler' that relying on flow persistence, aggregated upstream rainfall and travel time – to provide reliable flood forecasts comparable to relatively more complex methods for up to 10-days lead time for the Ganges, Brahmaputra, and Meghna (GBM) Rivers inside Bangladesh.
- Our results show comparable or better forecasting accuracy with respect to existing operational hydrologic, hybrid models or satellite altimetry-based forecast methods for these river basins.
- The proposed framework is of particular importance for large rivers, where access to upstream data are limited.

Authors:
[1] Civil and Environmental Engineering, Tufts University, Medford, MA
[2] Civil and Environmental Engineering, University of Rhode Island, Kingston, RI
[3] Water Diplomacy, The Fletcher School of Law and Diplomacy, Medford, MA

Corresponding authors: Shafiqul Islam (Shafiqul.Islam@tufts.edu)
Wahid Palash (Khan.Palash@tufts.edu)

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Tufts UNIVERSITY School of Engineering

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Anderson Hall, Tufts University, Medford, MA 02155, Tel: 617.627.4290

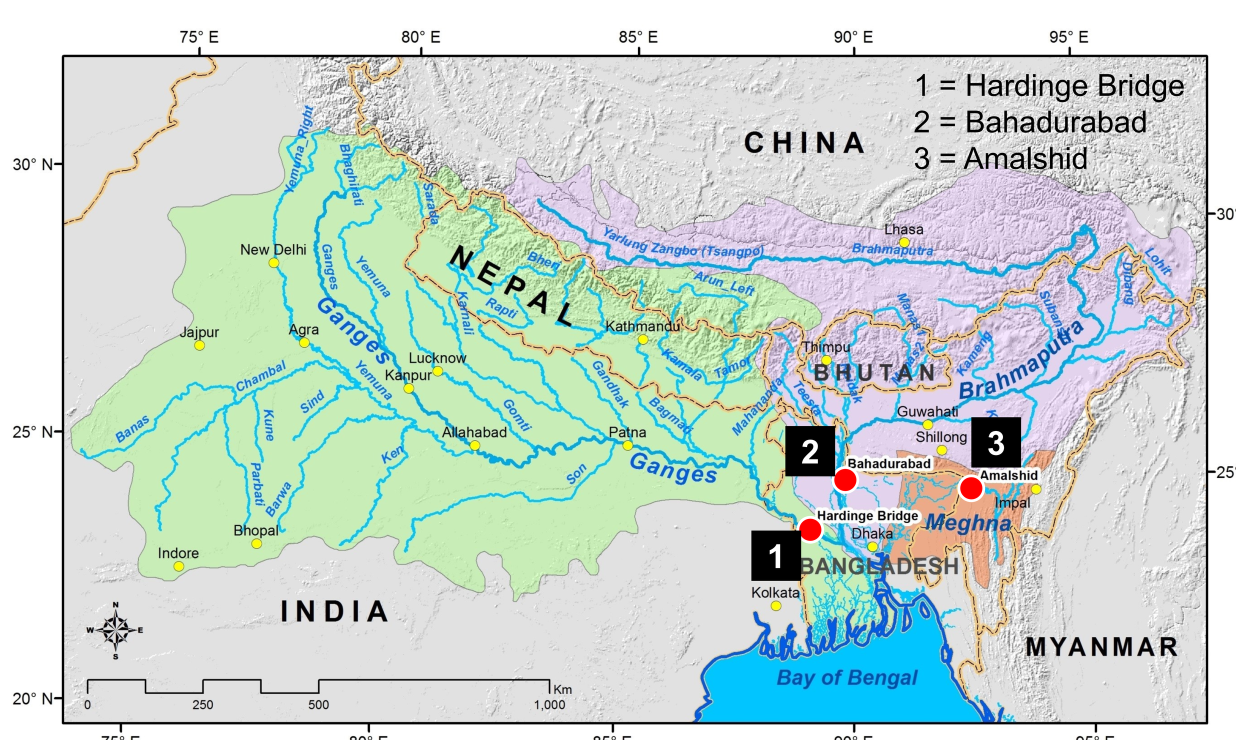
A Flood Forecasting Scheme for Large Rivers with Requisite Simplicity

Wahid Palash[1], Yudan Jiang[1], Ali S. Akanda[2], David L. Small[1], Amin Nozari[1], Shafiqul Islam[1,3]

Objective

- Provide improved streamflow and water level forecasts of the GBM basins at their most downstream gauging locations (i.e., Hardinge Bridge, Bahadurabad, and Amalshid, respectively) inside Bangladesh.
- Building on the notion of requisite simplicity, we aim to introduce a linear regression-based forecasting model for the GBM basins for 1-10 days lead time. We named it requisite simplicity (RS) flood forecast model or RS model.

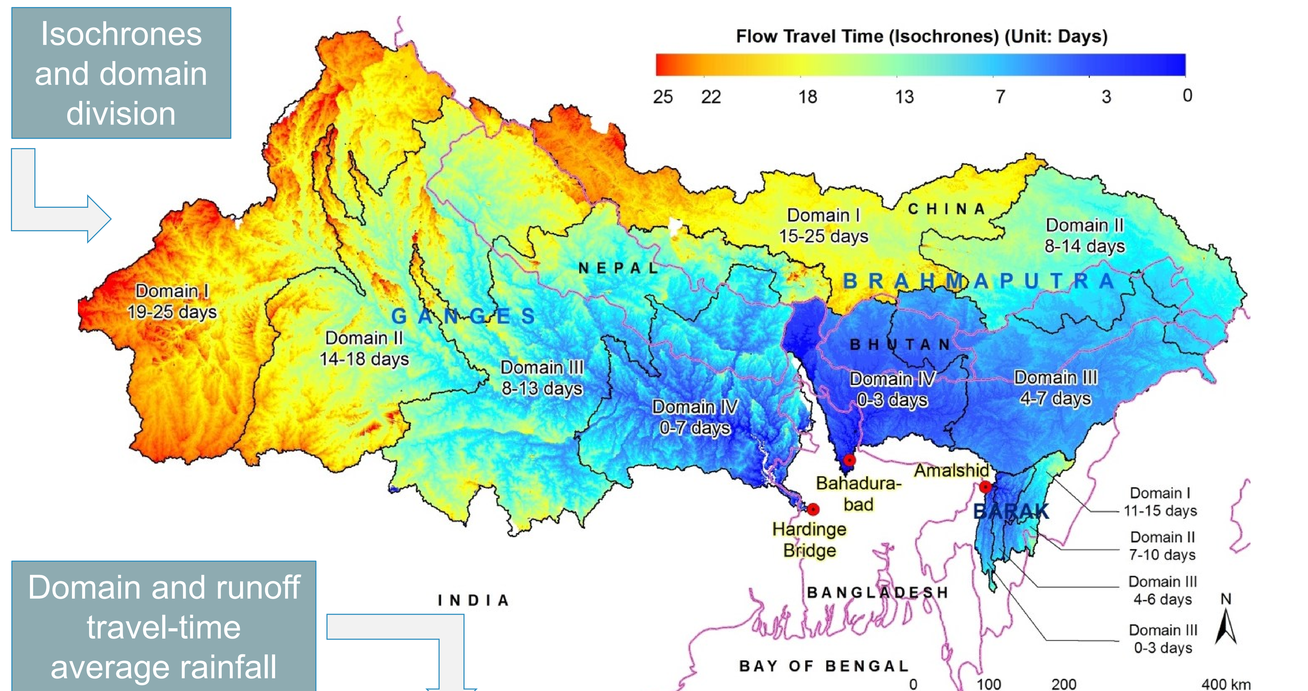
GBM river basins and forecast locations (shown as red circle)



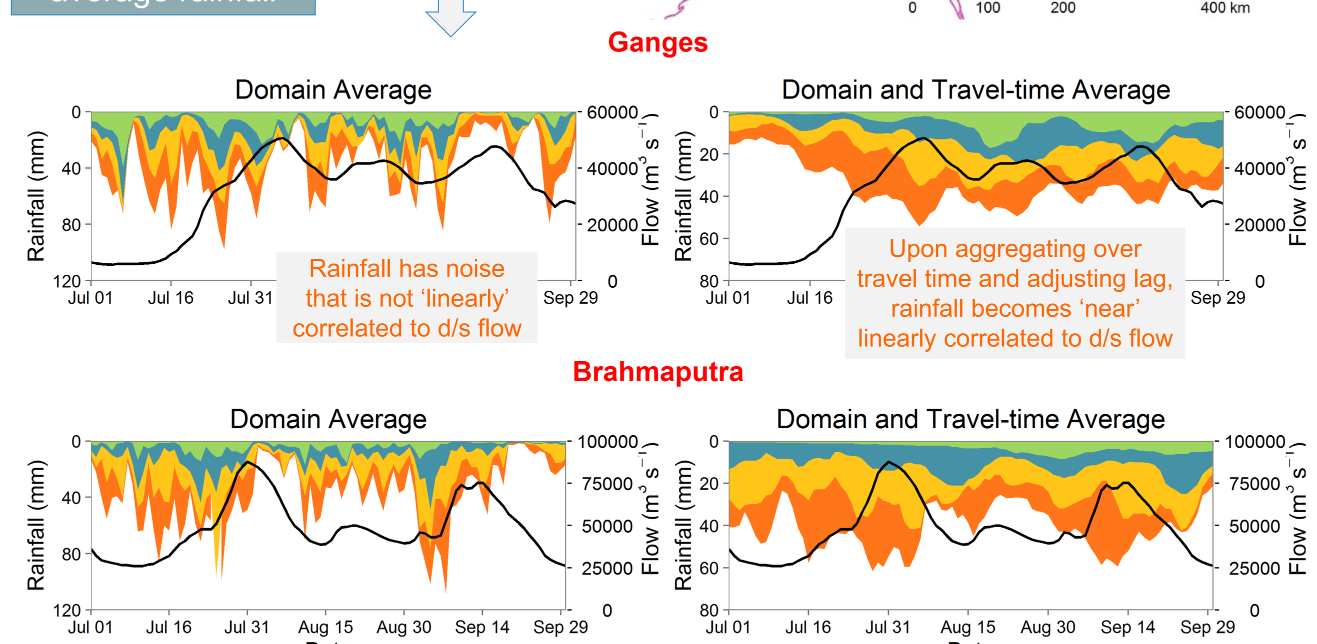
Methods

- Applied regression-based linear model by employing river flow persistence and upstream aggregated rainfall over broadly divided basin domains with runoff travel time lag adjustment.
- Generate isochrones (runoff travel time map) and divide basin into four large domains.
- Calculate domain (spatial) and domain's max & min runoff travel time (temporal) average TRMM rainfall to general four daily domain rainfall for the regression.
- Origin of forecast day and one day before measured stream flow or water level data provides flow or water level component of the regression.

Isochrones and domain division



Domain and runoff travel-time average rainfall

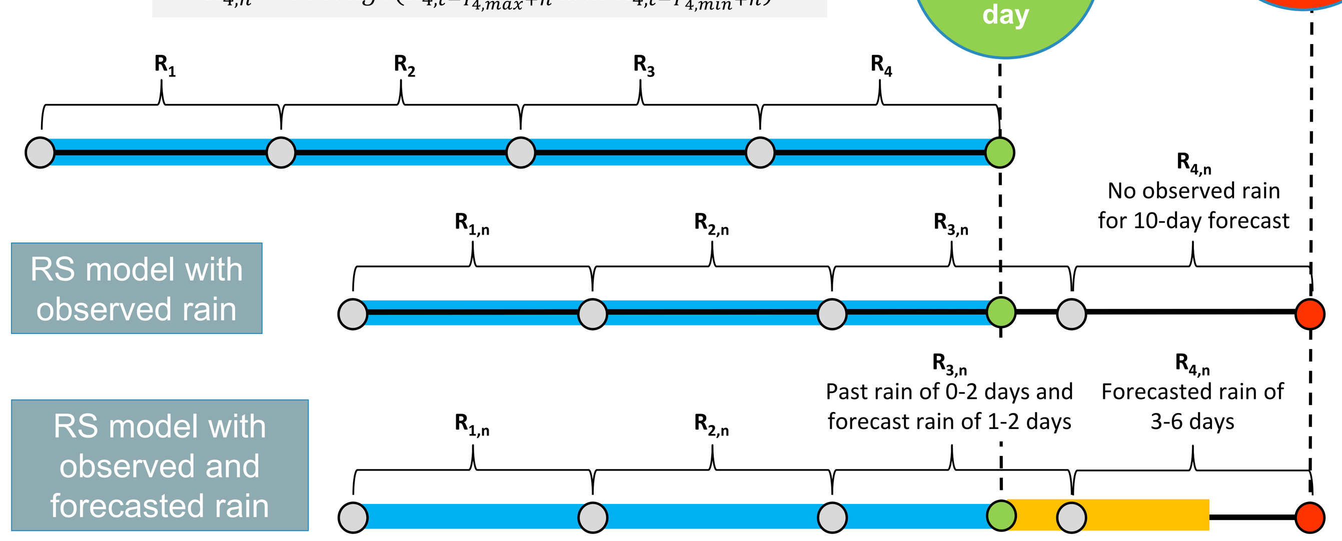


RS model regression structure

$$Q_{t+n} = \alpha_n Q_t + \beta_n Q_{t-1} + a_n R_1 + b_n R_2 + c_n R_3 + d_n R_4 + \gamma_n$$

Origin of forecast day flow or water level; Rainfall: Domain 1, Domain 2, Domain 3, Domain 4; Basin outflow — Flow; Forecast at n lead time; Previous days of origin of forecast day flow or river stage

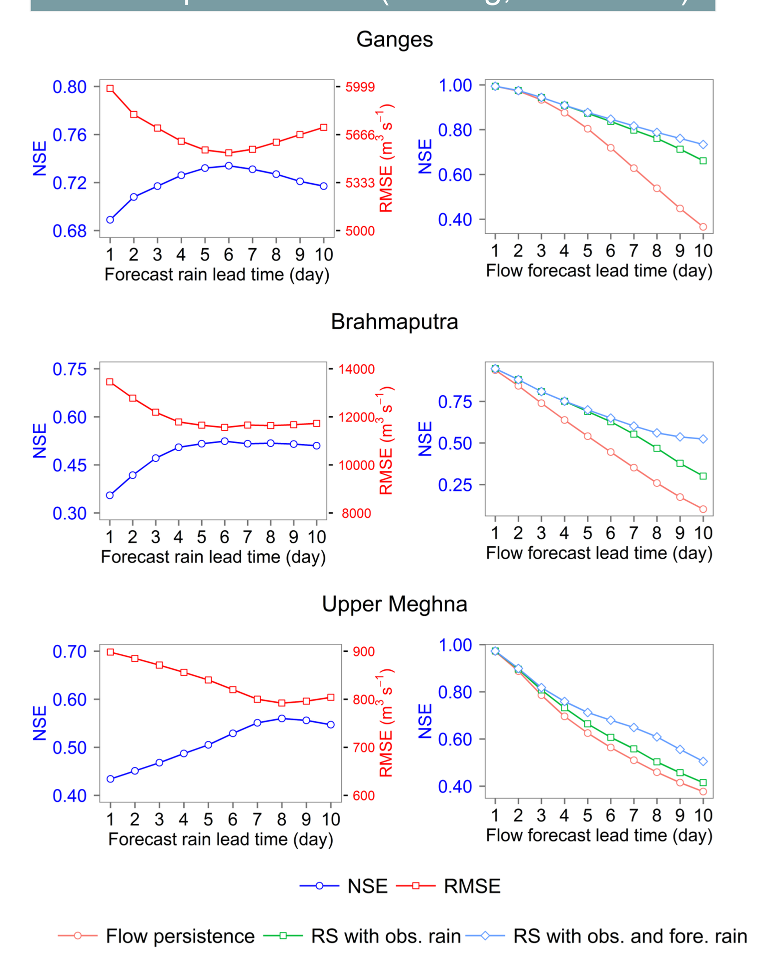
$$R_{1,n} = average(R_{1,t-T_{1,max}+n} \cdots R_{1,t-T_{1,min}+n})$$
$$R_{2,n} = average(R_{2,t-T_{2,max}+n} \cdots R_{2,t-T_{2,min}+n})$$
$$R_{3,n} = average(R_{3,t-T_{3,max}+n} \cdots R_{3,t-T_{3,min}+n})$$
$$R_{4,n} = average(R_{4,t-T_{4,max}+n} \cdots R_{4,t-T_{4,min}+n})$$



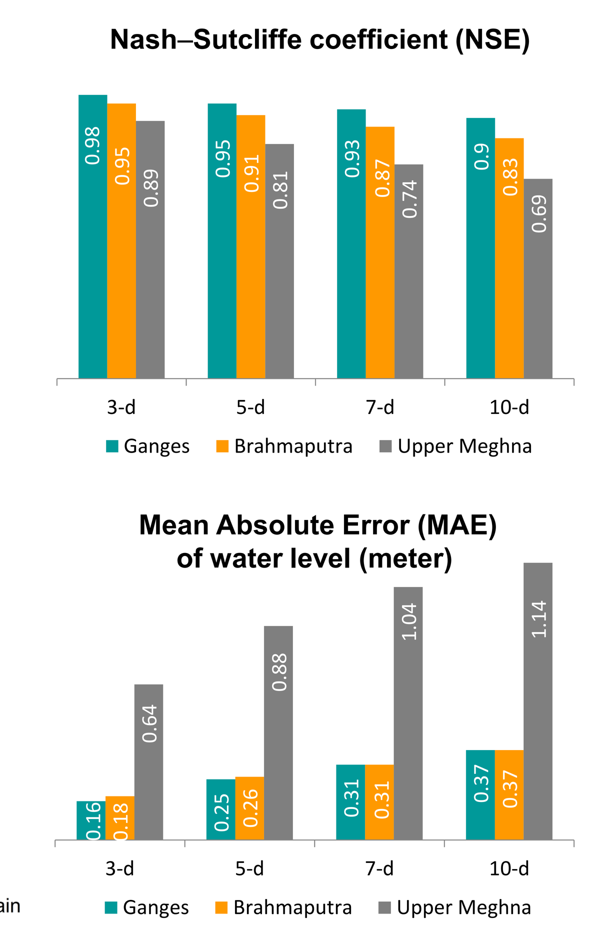
Results

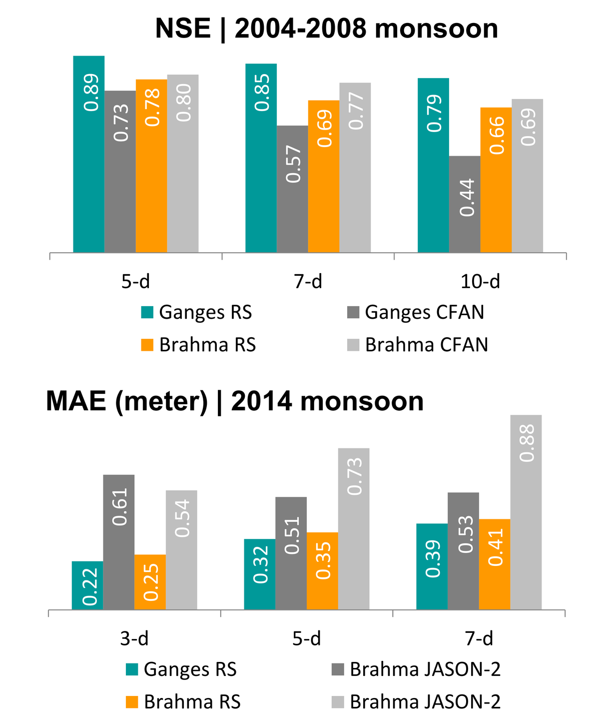
- The MAE and R^2 of the Ganges 10-days water level forecasts are 0.37 m and 0.9, respectively during flood season for 2007-2015. The corresponding values for the Brahmaputra are 0.37 m and 0.83, respectively.
- The forecast performance for the Meghna is limited to 5 or 7-days lead time with average MAE and R^2 is less than 1.0 m and over 0.75, respectively.

Contribution of adding upstream rainfall to forecast performance (Jul-Aug, 2007-2015)

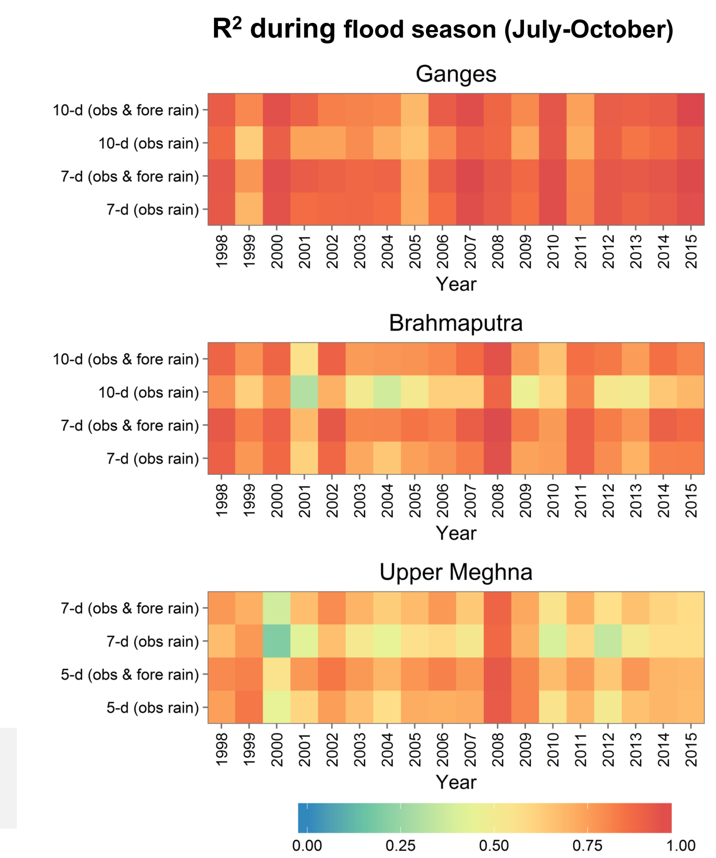


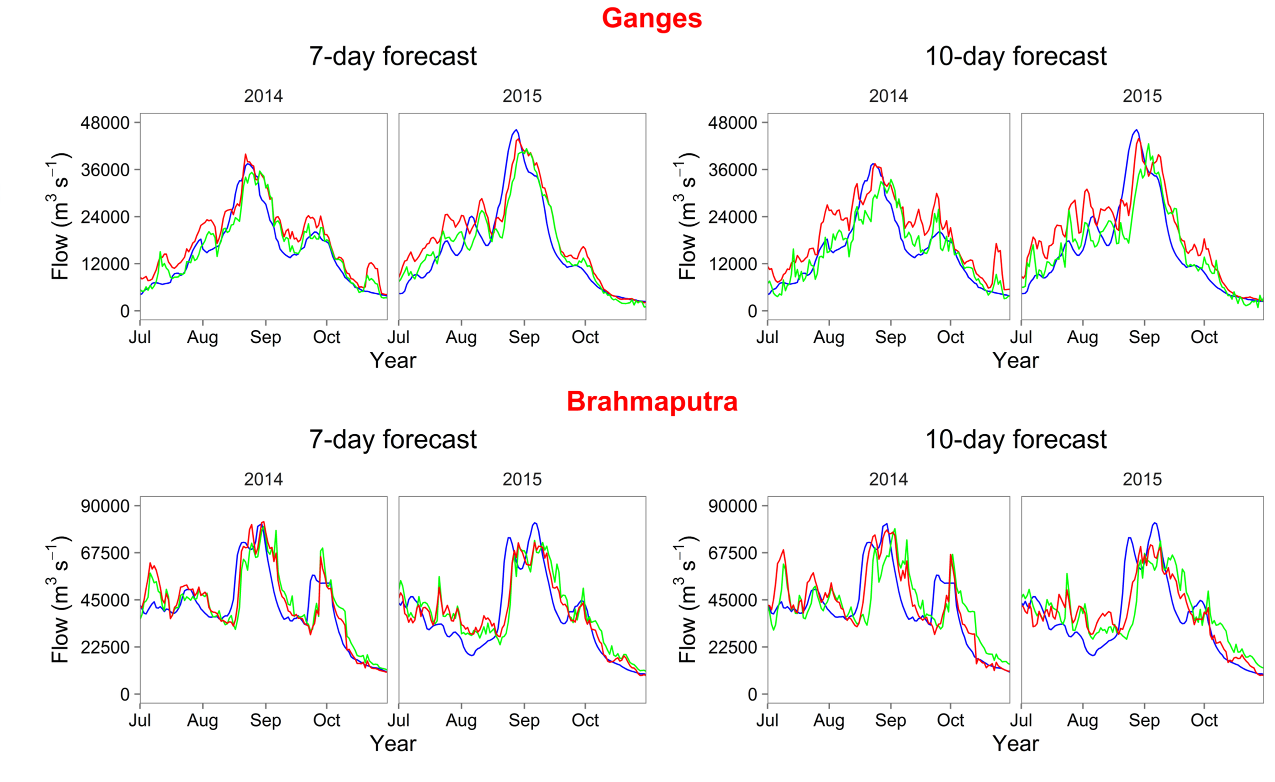
Important performance statistics (Jul-Oct, 2007-2015)

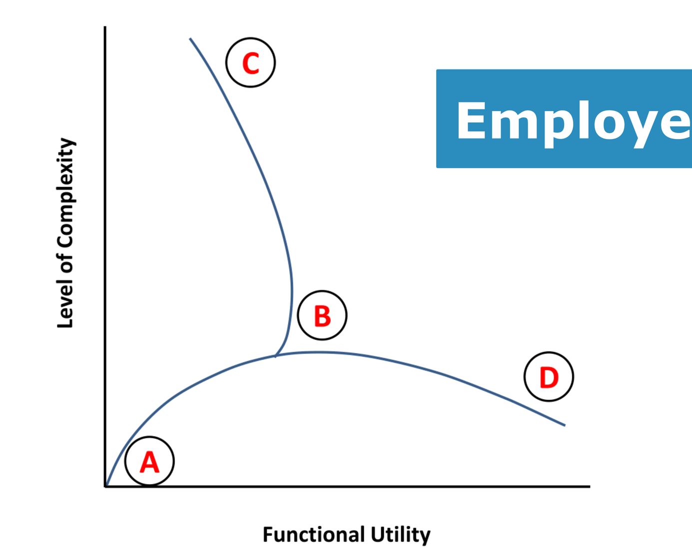




CFAN: Climate Forecast Application Network (Webster et al., 2010). JASON-2 Altimetry-derived water level forecast (Hossain et al., 2014).







- There is a perception that increased forecasting accuracy is achievable by increasing complexity of the model. This perception may lead us from Region **B** to **C** without appreciable change in functional utility.
- We argue that simplification may be achieved as we move from Region **B** to **D** by taking a closer look at the dominant processes for larger basins and reducing the model to its essential components.

Employed Requisite Simplicity

Moving from Region **B** to **D**

- Spatial and temporal average domain rainfall correlates nicely with d/s flow or WL.
- Applied available global dataset.
- 6-days forecasted rain is adequate for 10-days Ganges and Brahmaputra flood forecasting.

Conclusion

- RS model provides high forecast accuracy up to 10-days for the Ganges and Brahmaputra and 7-days for Meghna River.
- Large-scale weather captured in satellite estimates (TRMM) and weather model (WRF) are useful in a data-driven model to obtain skilled GBM forecasts.
- This model will have greater application in those basins where availability and access to upstream ground data are limited and detail hydrological modeling are expensive, resource intensive and operationally prohibitive.
- Easy to develop, implement and institutionalize for early flood warning operation.