A Satellite Observations and Numerical Modelling Based Integrated Flash Flood Forecasting System for North-East Region of Bangladesh

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Abstract

North-east region of Bangladesh is comprised of hilly transboundary rivers in the upstream and complex river network along with floodplain in the downstream. In this study, a satellite observation and numerical modeling based near real-time flash flood forecasting framework is developed for the north-east part of Bangladesh. For nowcast information, Global Precipitation Measurement Mission (GPM) developed latest near real-time IMERG precipitation product is chosen. To produce improved quality precipitation forecasts, Global Forecasting System (GFS) based precipitation predictions are corrected by applying climatology based bias adjustment technique. Flow from upstream river channels into the complex river network are calculated by using the nowcast and forecast precipitation products forced into Soil and Water Assessment Tool hydrological Model. The inflow discharges from the hydrological model then used in HecRAS hydrodynamic model to produce forecasted water height/discharge, flood depth and inundation in prominent locations in the study region. Both of the hydrological and hydrodynamic models are simulated sequentially in sub-daily scale to produce 120 hours lead time forecasts. SWAT Model was calibrated and validated in six inflow stations using rated discharge. HecRAS Model was calibrated and validated using measured water level at different locations.

A SATELLITE OBSERVATIONS AND NUMERICAL MODELLING BASED INTEGRATED FLASH FLOOD FORECASTING SYSTEM FOR NORTH-EAST REGION OF BANGLADESH

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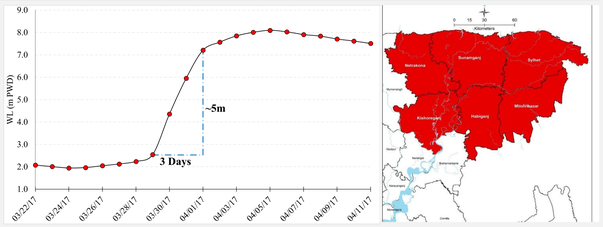
Background



2017 Flash Flood of Bangladesh
- About 1 million people affected
- Destroyed ready-for-harvesting 219,840 hectars crops
- About 3.7% of agriculture sector GDP

Requirements of Flash Flood Forecasting
- Very high accuracy of forecasts
- Minimum computational time and resources
- Based on publicly available models, datasets

Objective

Development of a computationally efficient and skillful flash flood forecasting and early warning system for the North-east region of Bangladesh using satellite observations and numerical weather prediction models.

Study Area

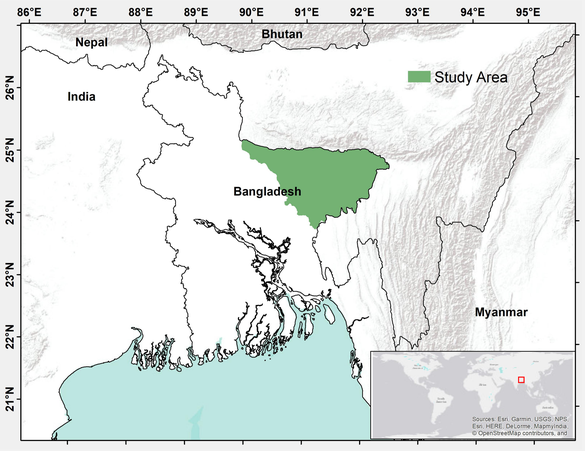


Figure 1: North-east region of Bangladesh

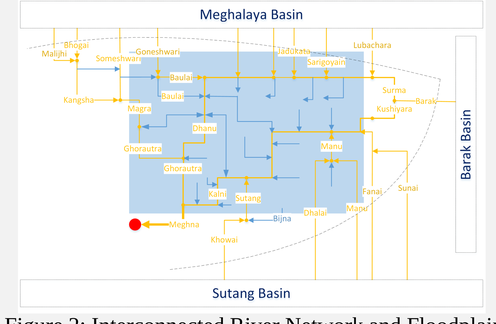


Figure 2: Interconnected River Network and Floodplain

Methodology

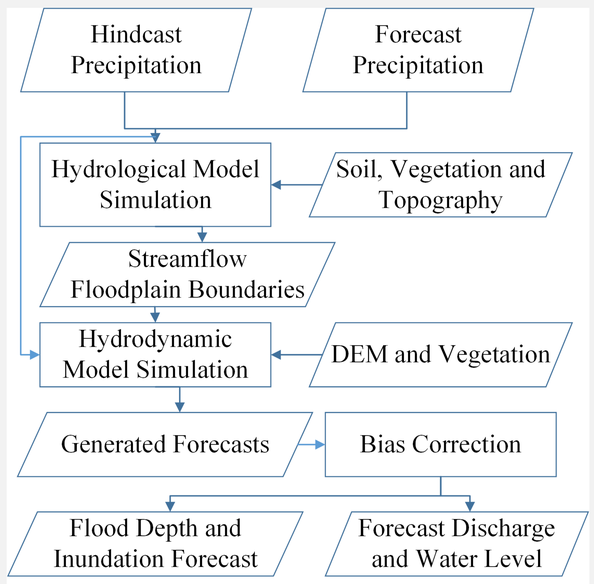


Figure 3: Methodology of Flash Flood Forecasting Framework

Hydrological Model: Soil and Water Assessment Tool (SWAT)
Hindcast Precipitation: GPM IMERG Early Run Product
Forecast Precipitation: Global Forecasting System (GFS)

Hydrodynamic Model: HecRAS
- Simulated over reconditioned and corrected SRTM Dem
- Hindcast + forecast Precipitation over floodplain used

Bias Correction Technique

$bias = WL_{simulated}[x] - WL_{observed}[x]$

$WL_{forecast}[i] = WL_{simulated}[i] - bias$

where, x = forecast date, i = forecast lead time

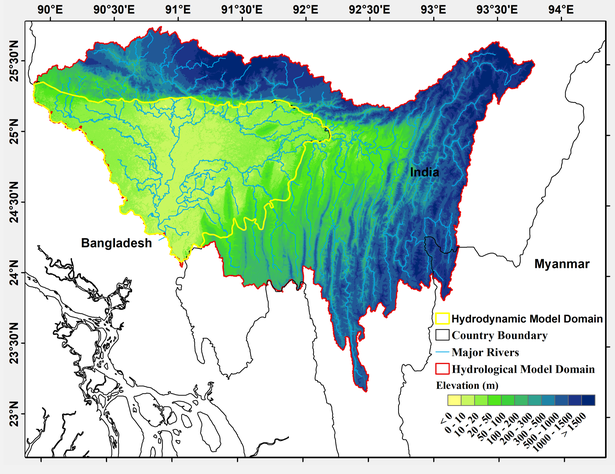


Figure 4: Hydrologic and Hydrodynamic Model Domain

Simulation of Flash Flood, March 2017

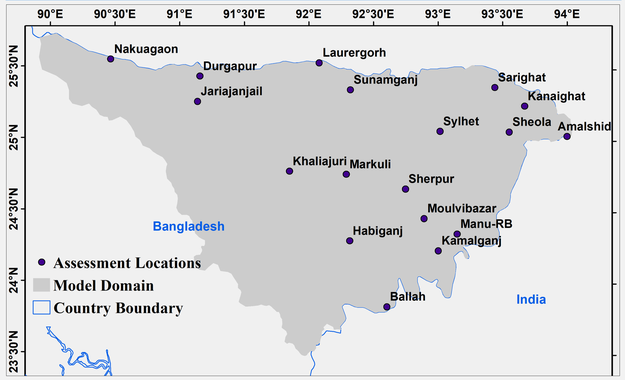


Figure 5: Station Locations for Model Forecasts Comparison

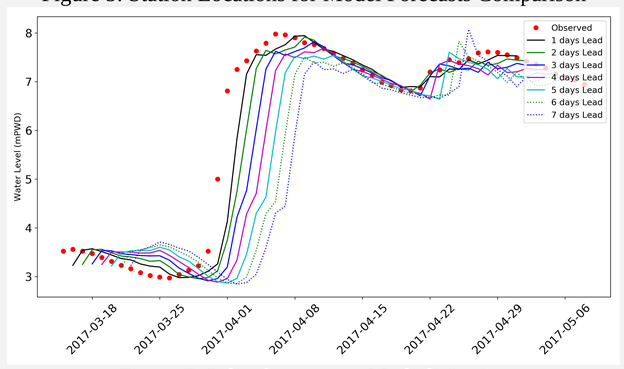


Figure 6: 5 day forecasts at Markuli Station

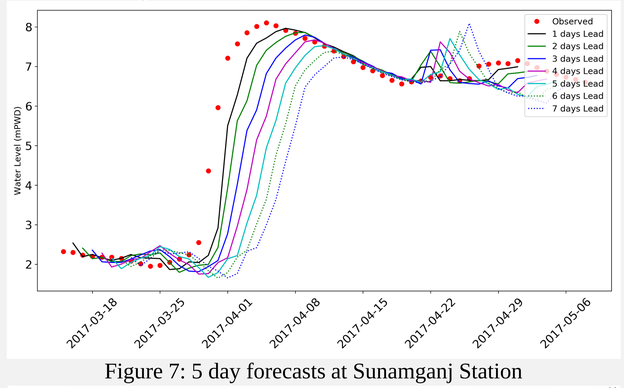


Figure 7: 5 day forecasts at Sunamganj Station

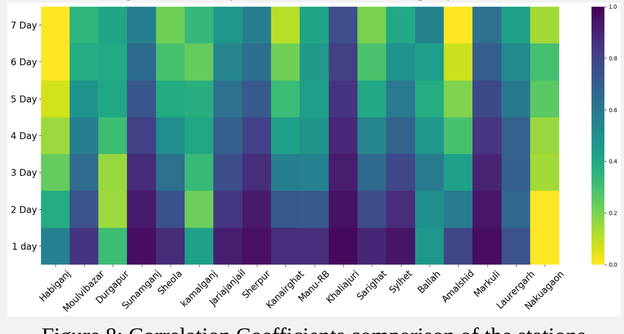


Figure 8: Correlation Coefficients comparison of the stations

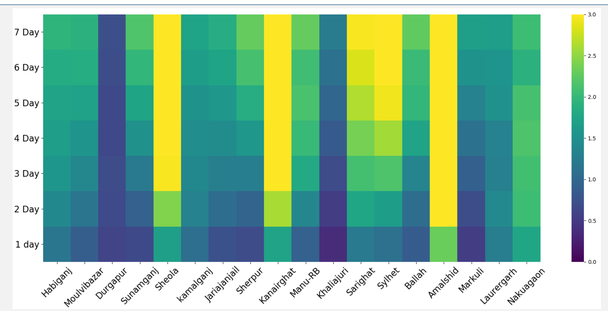


Figure 9: Root Mean Square Error Comparison

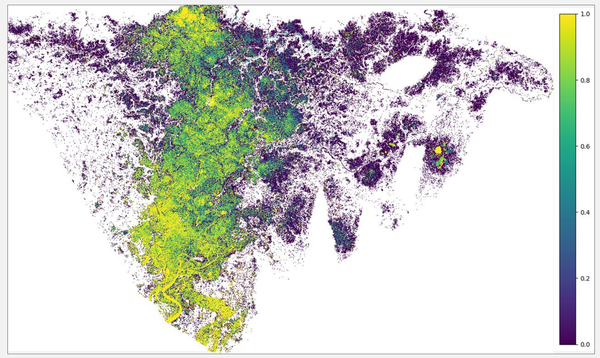


Figure 10: Probability of Detection of simulated inundation compared to Sentinel 1 Imagery (0 is worst, 1 is perfect)

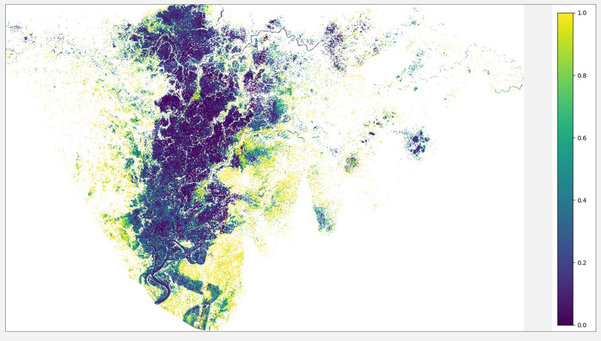


Figure 11: False Alarm Ratio of simulated inundation compared to Sentinel 1 (SAR) Imagery (0 is perfect, 1 is worst)

Conclusion and Future Scope

- Modelling Framework forecasts flood up-to 5 days lead time with very high accuracy.
- Reconditioned and corrected SRTM DEM along with bias correction technique yields better forecast.
- Hindcast and forecast precipitation correction, hydrodynamic model resolution and simulation step can improve forecast accuracy.

Reference

Biswas, N. and Hossain, F., (2019). A satellite observations and numerical modelling based integrated flash flood forecasting system for north-east region of Bangladesh (in preparation)