Flood Forecasting Model Enhancement to increase forecast lead-time with GloFAS forecasting in Bangladesh

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Objectives

- Enhance Flood Forecasting and Warning Centre (FFWC) water level forecast performance for rive basins in Bangladesh.
  - Select forecast boundary conditions in a more systematic way by improving the GloFAS forecast bias and incorporating it into the FFWC hydrodynamic model (Flood Forecast model).
- Provide a proof of concept of how the FFWC model could be improved using global forecasts.
- Continue to foster technical cooperation between FFWC and GloFAS.

Annual variations of floods and GloFAS forecasts
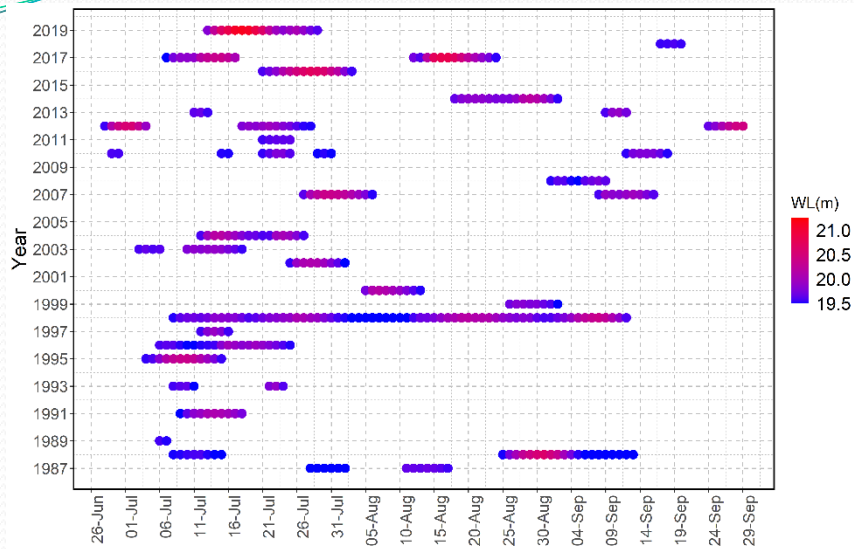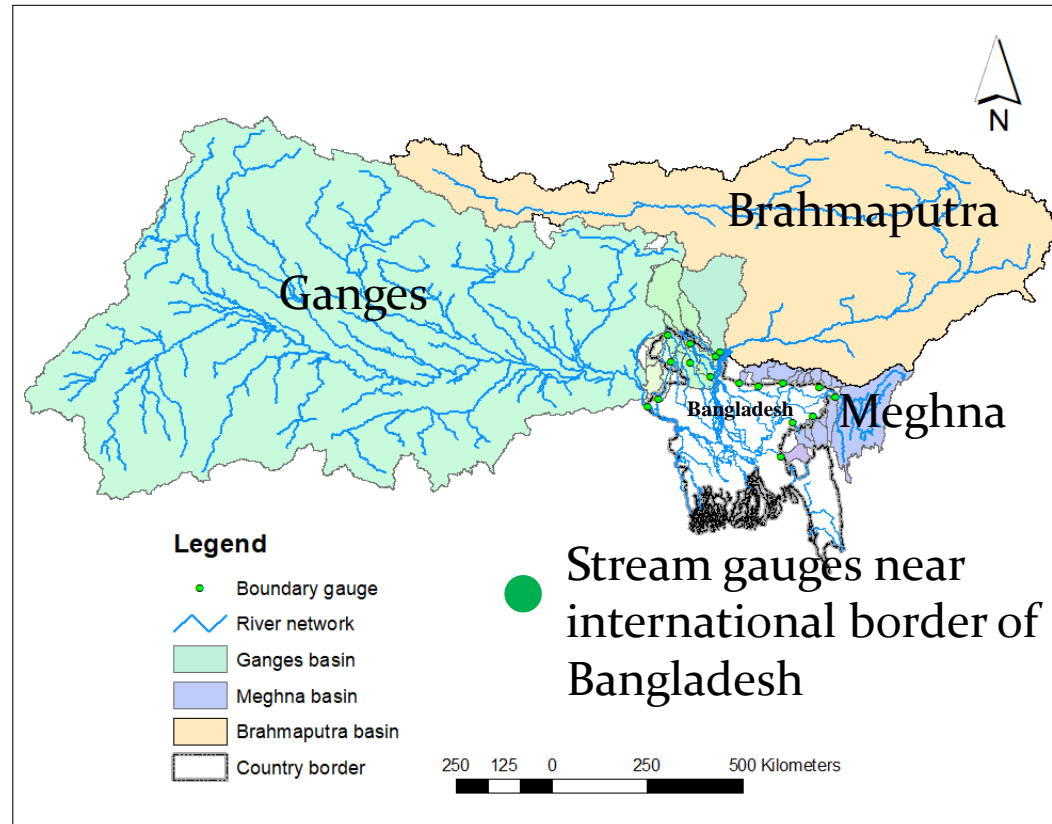

Brahmaputra River   (Hossain et al. 2021)
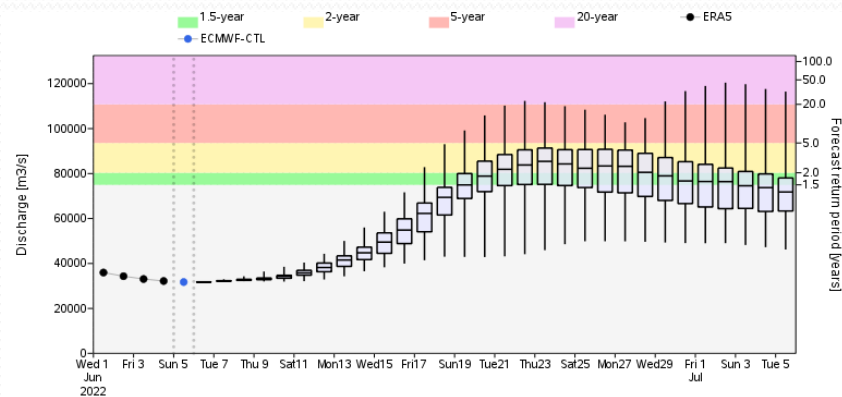
GloFAS 30 days forecast

Brahmaputra, Bahadurabad stream gauging

- Large annual variation of floods in terms of magnitude, time of occurrence and duration.

- Difficult to predict flood duration and timing with short-range forecast.

- GloFAS provides extended range river discharge forecast and provides useful forecast information for transboundary basins.

Transboundary catchments and Bangladesh

Stream gauges near international border of Bangladesh

Legend
- Boundary gauge
- River network
- Ganges basin
- Meghna basin
- Brahmaputra basin
- Country border

250 125 0 250 500 Kilometers

- Bangladesh is located at the downstream of three large river basins- Ganges-Brahmaputra-Meghna

- Floods depend on the upstream flows

- Challenge to increase lead-time due to limited upstream hydrometeorological data

Forecasting approach in Bangladesh

Initial condition
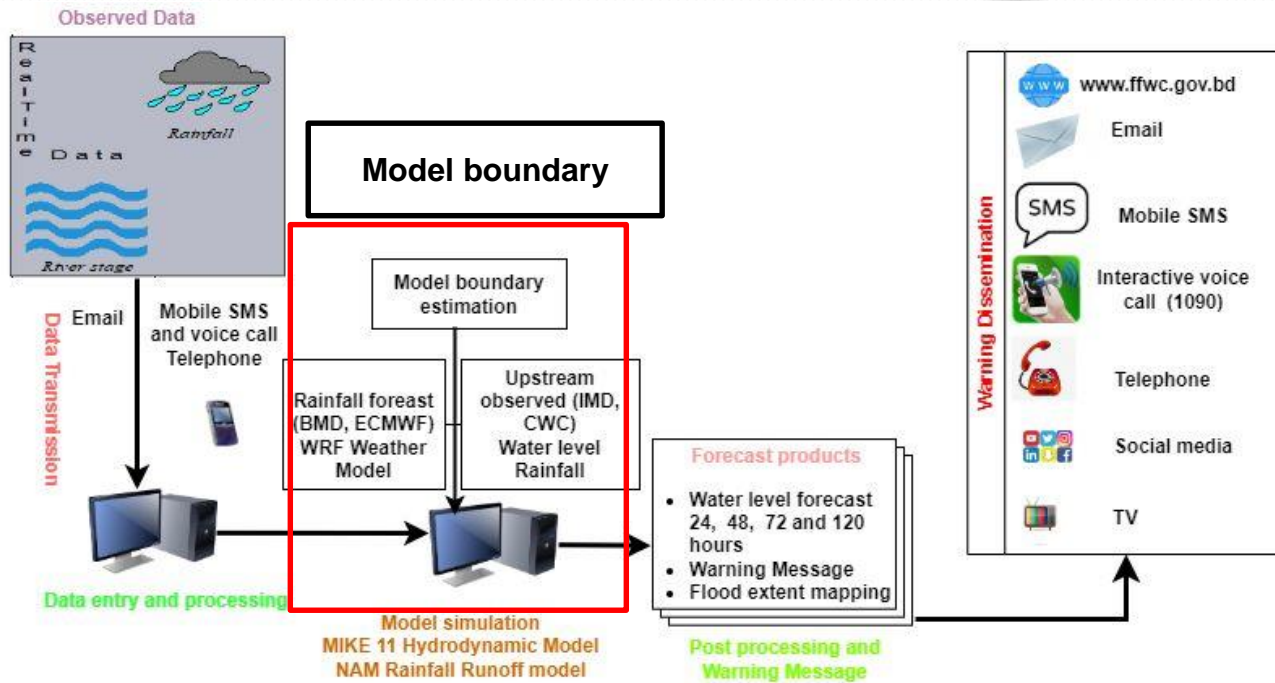
(Hossain et al. 2022)

- Forecast is provided in terms of water level simulated by MIKE 11 hydrodynamic modelling tool

- Model requires initial and boundary conditions

- It is a forecaster challenge to provide boundary estimation for flood model simulation
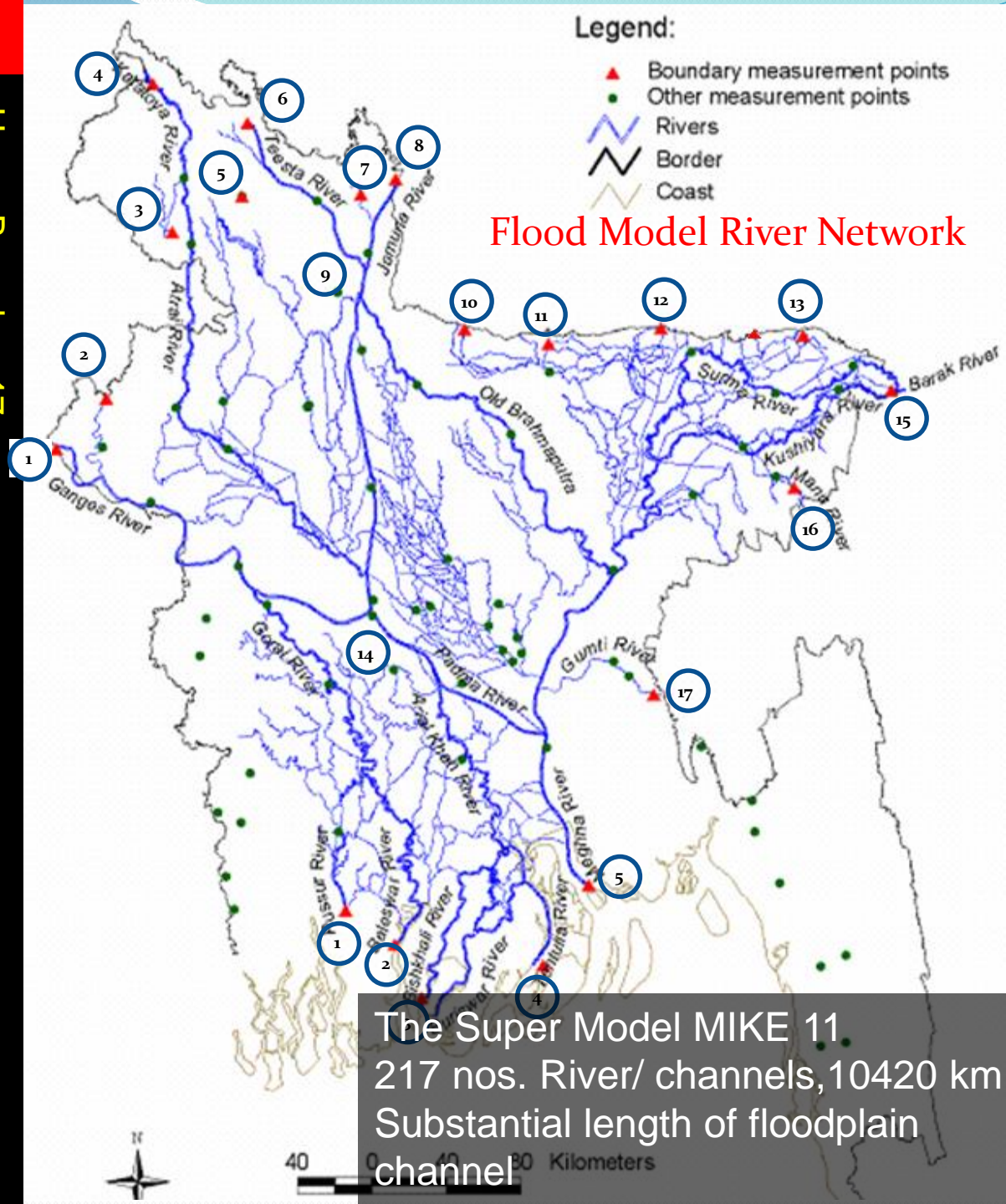
Model Boundary

Non-Tidal

1. **Pankha (Ganges)**
2. **Rohanpur (Mohanada)**
3. **Dinajpur (Punrobhaba)**
4. **Panchagar(Korotya)**
5. **Badarganj(Jamuneshery)**
6. **Dalia (Teesta)**
7. **Kurigram (Dharla)**
8. **Nonkhawa (Brahmaputra)**
9. **Gaibandha (Ghagot)**
10. **Nakuagaon (Bhugai)**
11. **Durgapur(Someswari)**
12. **Lorergarh (Jadukhata)**
13. **Sarighat (Sarigowain)**
14. **Faridpur (Kumar)**
15. **Amalshid (Kushiyara**
16. **Manu Railway Bridge (Manu)**
17. **Comilla (Gumti)**

Tidal

1. **Monghla (Passure)**
2. **Ryanda(Baleshwer)**
3. **Patharghat(Biskhali)**
4. **Dosmina(Tetulia)**
5. **Daultkhan(Meghna)**

Upper Boundary 17

Lower Boundary 5

Legend:
▲ Boundary measurement points
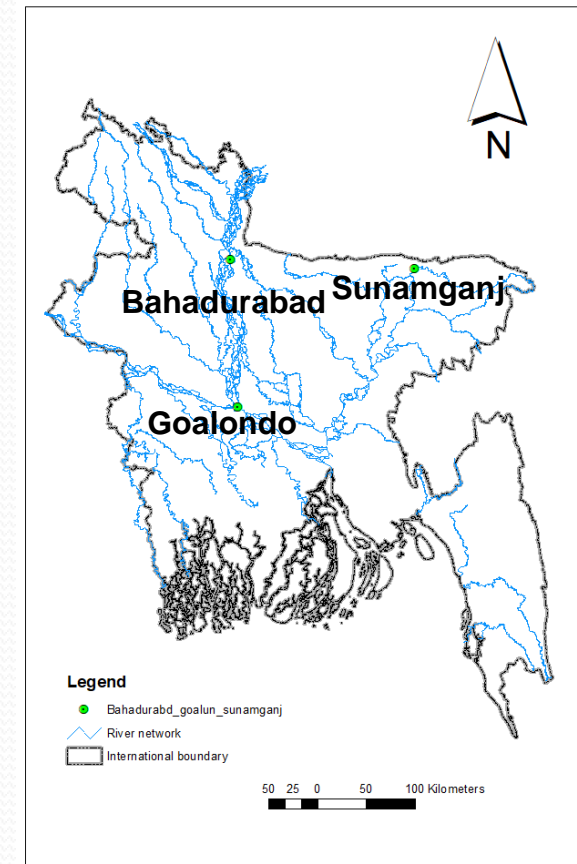● Other measurement points
⌇ Rivers
⌇ Border
⌇ Coast

Flood Model River Network

The Super Model MIKE 11
217 nos. River/ channels,10420 km
Substantial length of floodplain channel

How FFWC Forecasting Model Works with the GloFAS forecasts

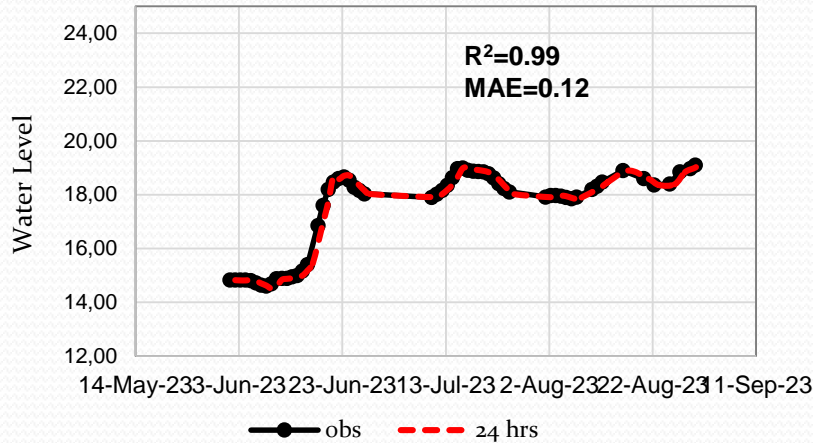GloFAS provides river discharge forecast, however, users in Bangladesh are familiar water level forecast.

➢ Employing ensemble river discharge forecasts from GloFAS for a 30-day period

➢ Incorporating the GloFAS discharge forecasts into the FFWC model

➢ The model simulates the discharge forecasts to generate forecasted water levels

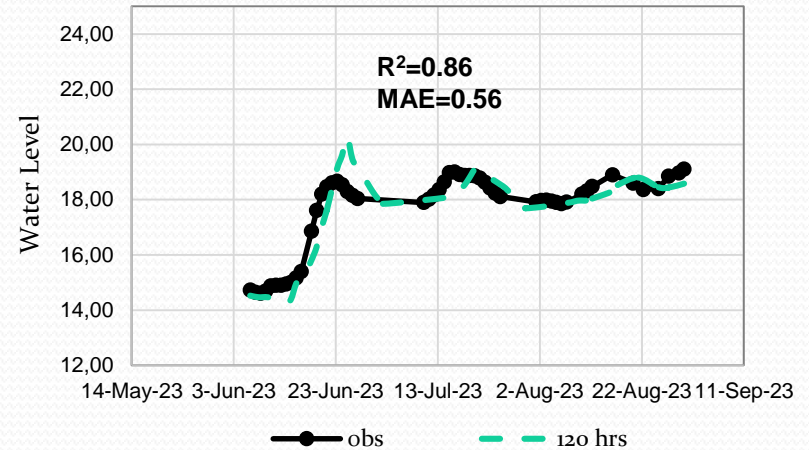➢ Outputting a 15-day water level forecast based on the integrated GloFAS and FFWC model

Legend
- Bahadurabd_goalun_sunamganj
- River network
- International boundary

50 25 0 50 100 Kilometers

Three forecast stations in Bangladesh

Bahdurabad (Brahmaputra) forecasted water level Vs observed water level for June, July and August 2023

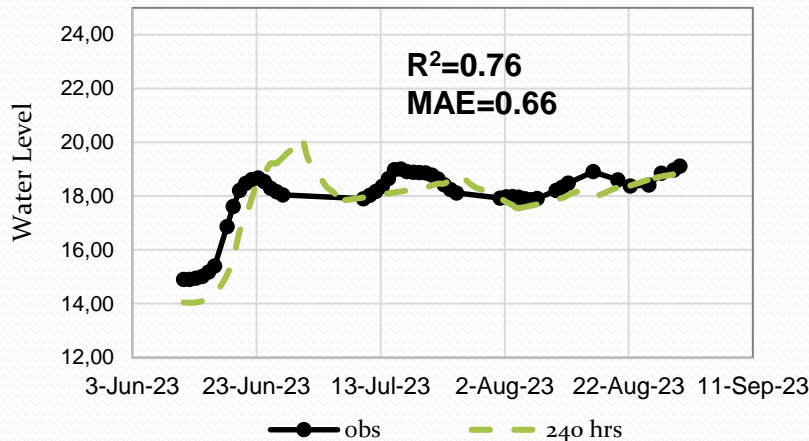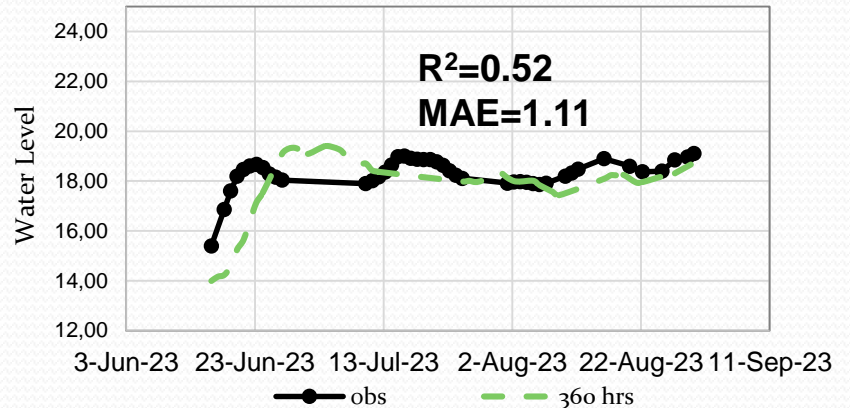**Lead time: 24 hrs**

R²=0.99
MAE=0.12

Water Level

24,00 — 22,00 — 20,00 — 18,00 — 16,00 — 14,00 — 12,00

14-May-23 3-Jun-23 23-Jun-23 13-Jul-23 2-Aug-23 22-Aug-23 11-Sep-23

●—— obs   ● ● ● 24 hrs

Lead time: 120 hrs

R²=0.86
MAE=0.56

Water Level

24,00 — 22,00 — 20,00 — 18,00 — 16,00 — 14,00 — 12,00

14-May-23 3-Jun-23 23-Jun-23 13-Jul-23 2-Aug-23 22-Aug-23 11-Sep-23

●—— obs   ● ● ● 120 hrs

Lead time :240 hrs

R²=0.76
MAE=0.66

Water Level

24,00 — 22,00 — 20,00 — 18,00 — 16,00 — 14,00 — 12,00

3-Jun-23 23-Jun-23 13-Jul-23 2-Aug-23 22-Aug-23 11-Sep-23

●—— obs   ● ● ● 240 hrs

Lead time: 360 hrs

R²=0.52
MAE=1.11

Water Level

24,00 — 22,00 — 20,00 — 18,00 — 16,00 — 14,00 — 12,00

3-Jun-23 23-Jun-23 13-Jul-23 2-Aug-23 22-Aug-23 11-Sep-23
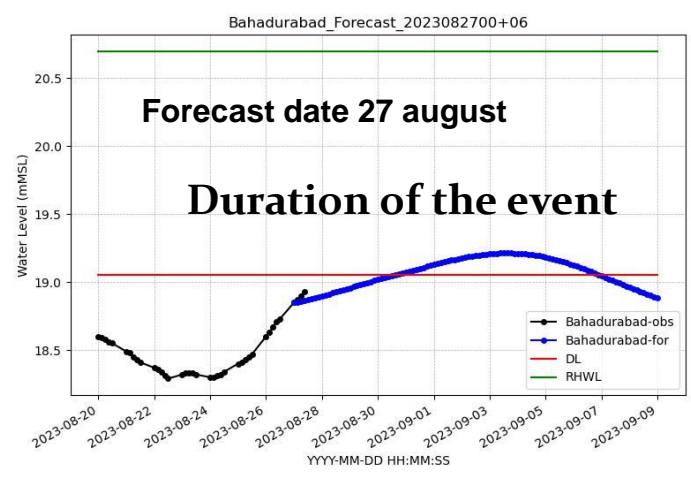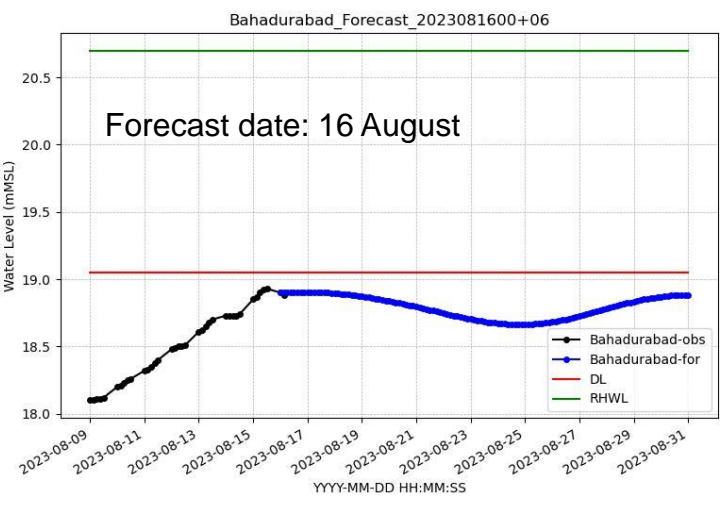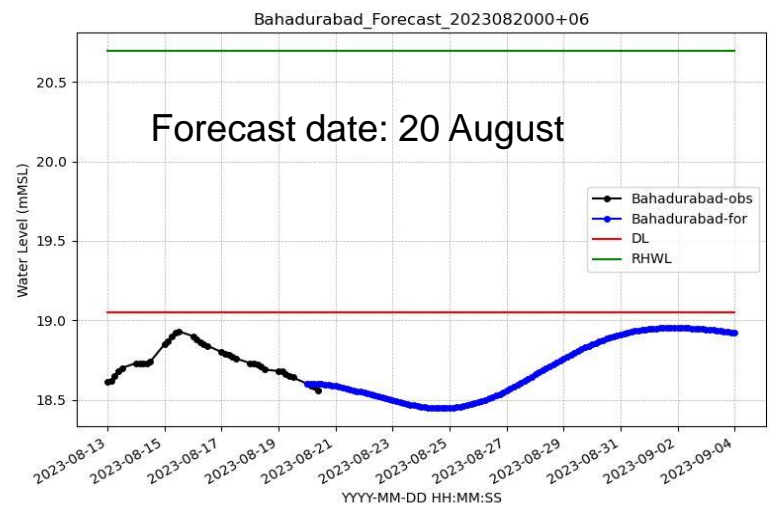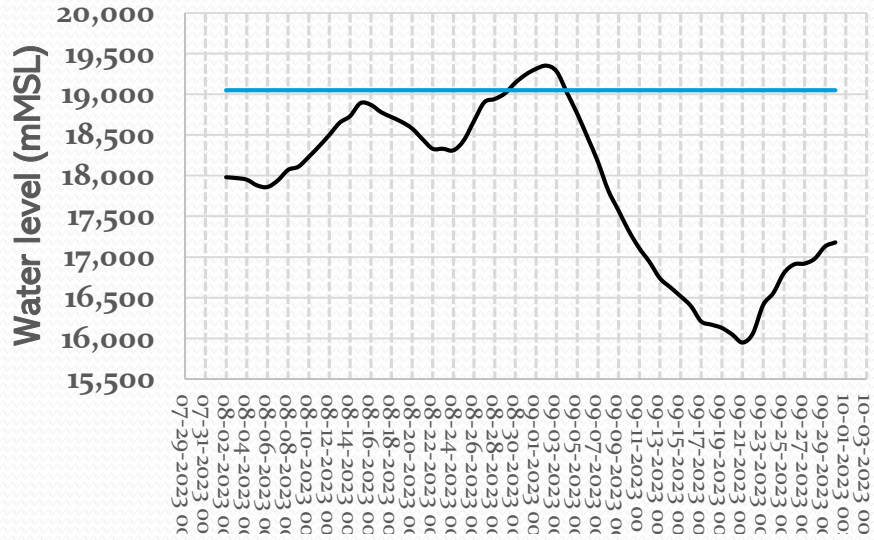
●—— obs   ● ● ● 360 hrs

- Out of 51 ensemble, at first stage only mean was used to simulate by the MIKE 11 hydrodynamic model
- R^2 is within very good for lead-time upto 10 days and decrease in 15 days lead time
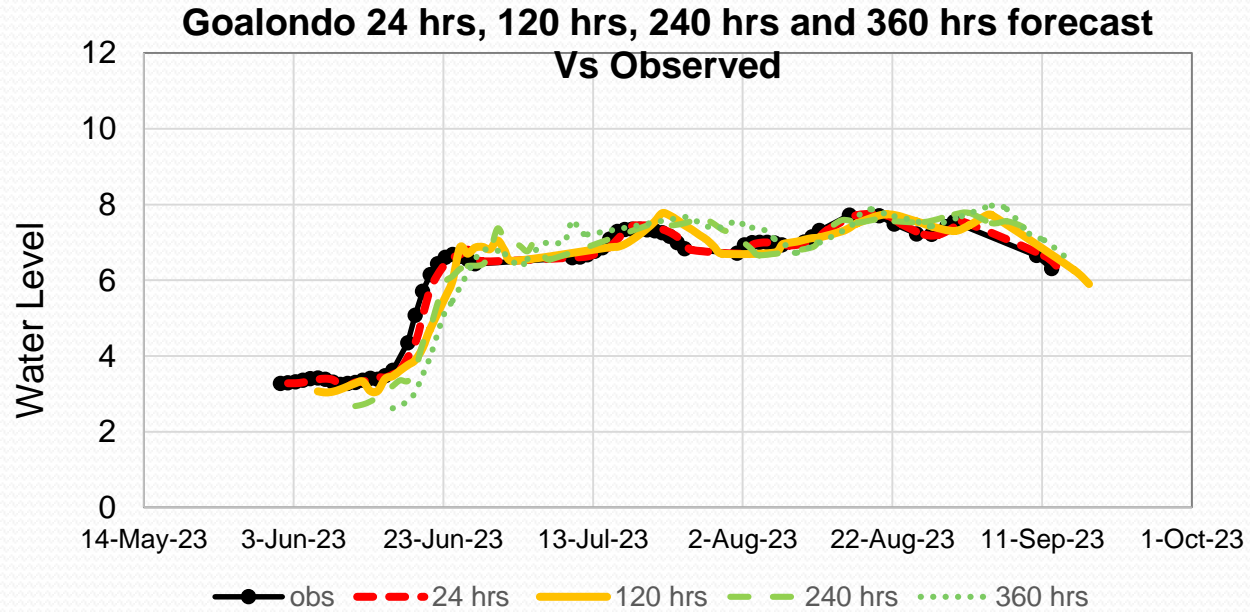
# 2023 flood peak flow simulation (Bahadurabad)

Observed Hydrograph

- Clearly simulate the annual peak events with lead time ~ 12-13 days

Goalondo (Padma) forecast water level Vs observed water level for June, July ,August and September 2023

Goalondo 24 hrs, 120 hrs, 240 hrs and 360 hrs forecast Vs Observed

- Forecast performance is better ($R^2 > 0.70$) at Goalondo (~180 km down stream of Bahadurabad station)

Sunamganj (Flash flood catchment) forecast water level Vs observed water level for June, July, August and September 2023

Sunamganj obs Vs 24 hrs, 120 hrs, 240 hrs and 360 hrs forecast
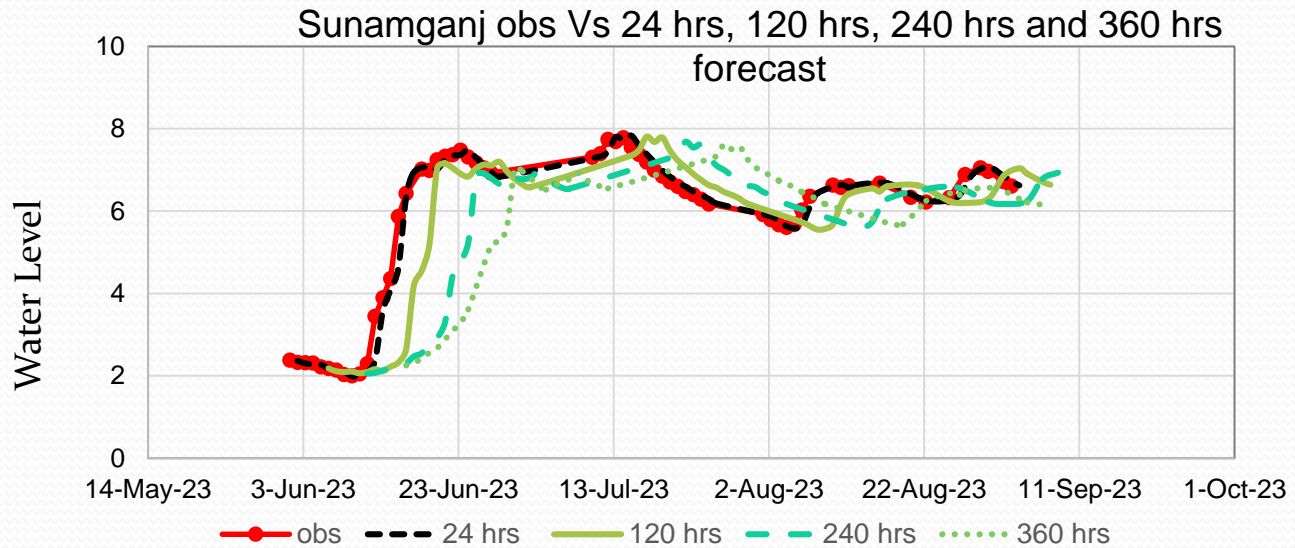
- Peaks shift more with the increasing lead rime

Summary

- Model capable to simulate water level based on input from GloFAS discharge forecasts

- GloFAS forecasts can be applied successfully to increase lead time of national flood forecasting model e.g., where needs upstream flow input as boundary

- In this stage, model is simulated 15 days lead time out of 30 days and mean ensemble is used.

- Operational simulation of FFWC (Bangladesh) model during the monsoon 2024 with all ensembles (Planned)