REAL-TIME FLOOD FORECASTING USING ECMWF ENSEMBLE PRECIPITATION FORECAST IN THE UPPER NAN RIVER BASIN, THAILAND

Thatkiat Meema[1,2]* and Yasuto Tachikawa[1]

[1]Department of Civil and Earth Resources Engineering, Kyoto University, Kyoto, Japan

[2]TEAM Consulting Engineering and Management Public Company Limited, Bangkok, Thailand

E-mail: thatkiat.meema@gmail.com

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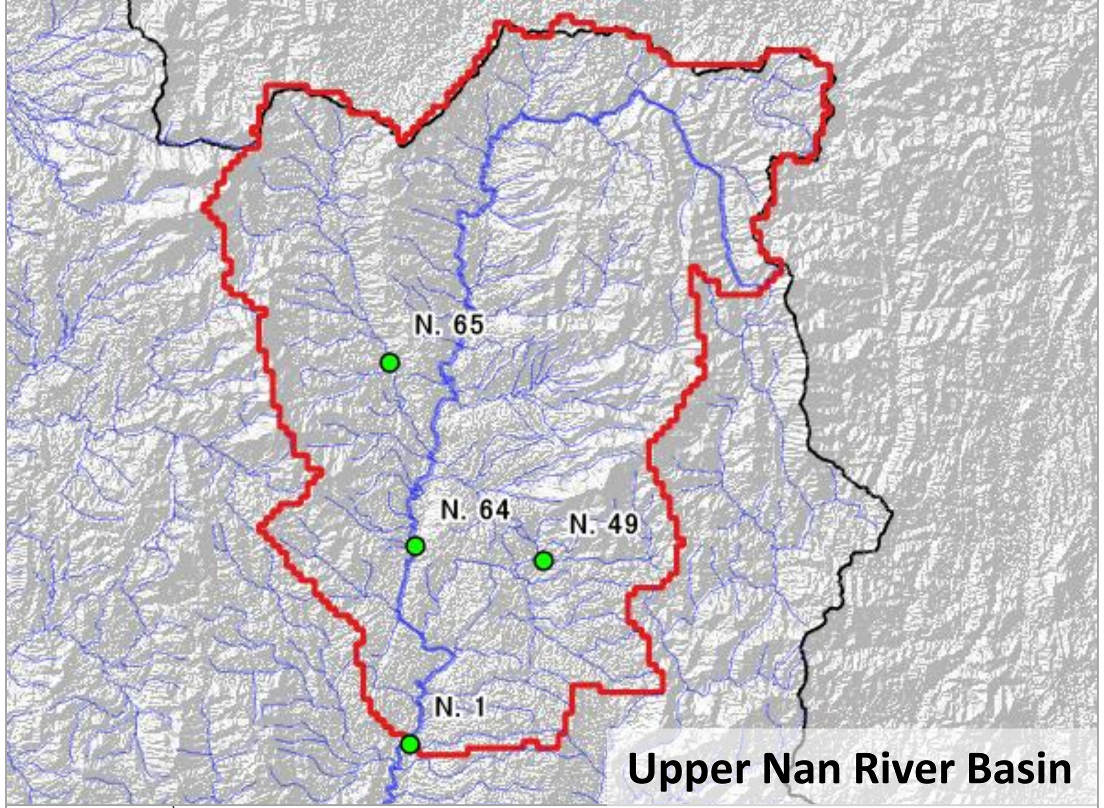
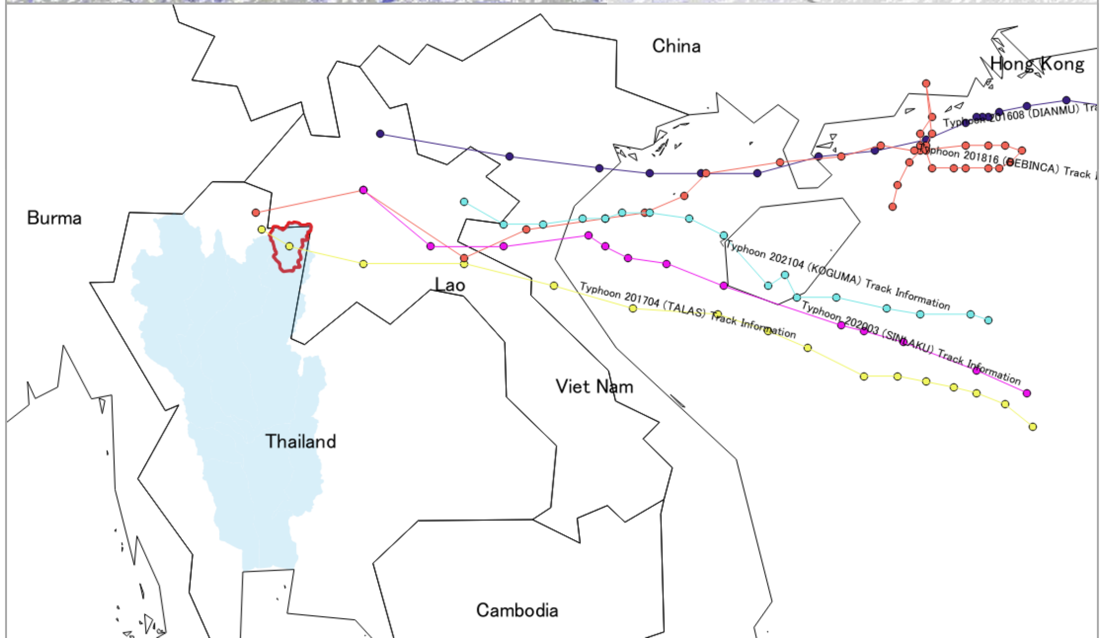




Introduction (1)

- frequently **experienced with high rainfall intensity** due to tropical storms (Typhoon).
- For example, in recent years; Dianmu 2016, Talas 2017, Bebinca 2018, Sinlaku 2020 and Koguma 2021.
- The catchment has a **steep slope in topography**.
- the basin is **vulnerable to flood disasters**.

Introduction (2)

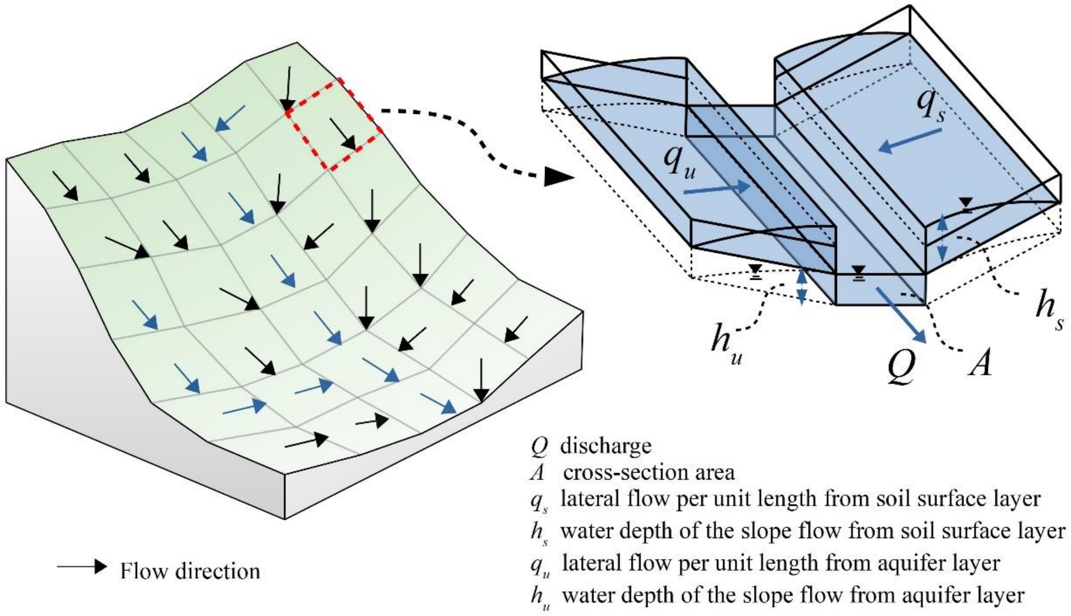
- To mitigate the extensive damage and disruption to societies caused by floods, **forecasting is an effective means** to **provide timely hazard information**.
- However, the **forecast has limitations** in accuracy (forecast uncertainty) with **increasing forecast lead time**.
- Instead of deterministic forecasting, **probabilistic forecasting with Ensemble Prediction System (EPS)** has advanced in the last decade.

Objectives

- We aim to develop the *real-time forecasting scheme* using **ensemble precipitation forecasting** (**EPF**) with **a distributed hydrological model (DHM)**.
- How well can we **forecast the flood hydrograph** using **medium-range EPF**?

Prediction model

Improved 1K-DHM *(Meema and Tachikawa, 2020)* was applied for this study.

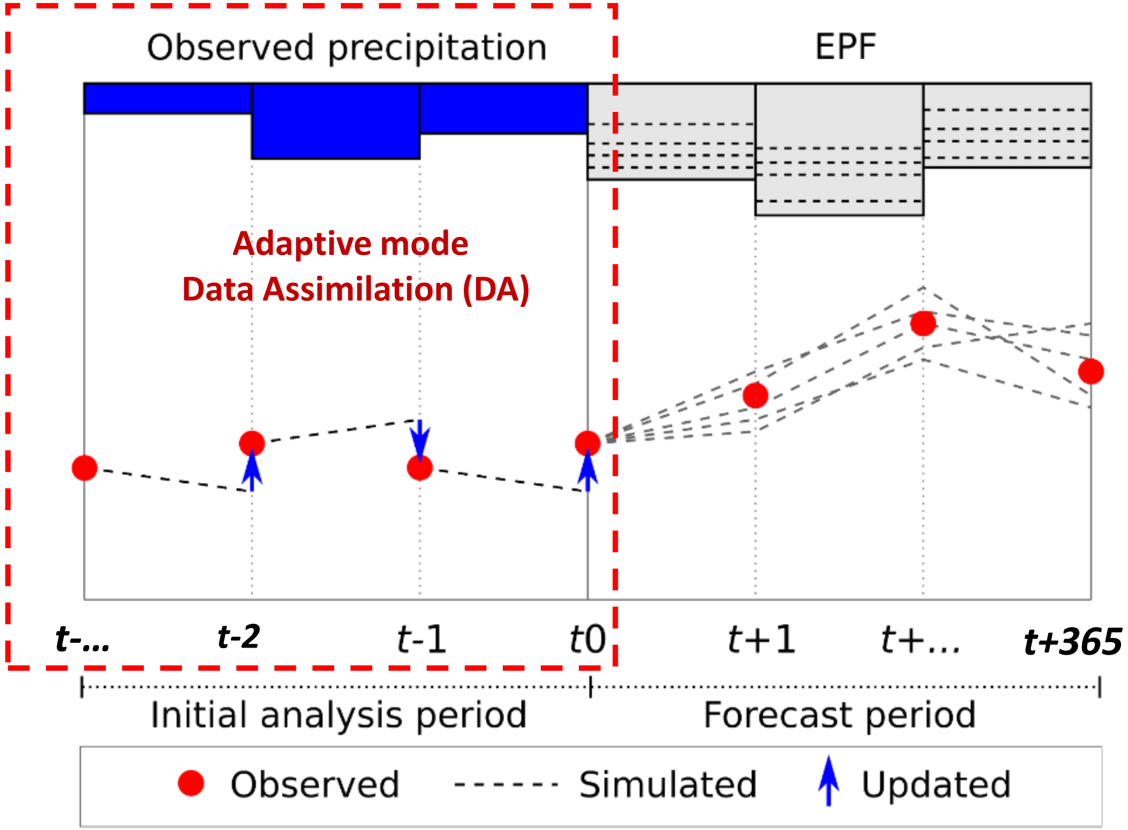


- Using the physical-based **Distributed Hydrological Model** (DHM) for real-time flood forecasting **has an advantage in the spatial distribution of the forecast output**.
- The severe **storm events in 2016, 2017 and 2018** were collected **for model calibration and validation**.
- The **SCE-UA algorithm** has been **adopted for calibration** by searching for the parameters which minimize RMSE.

T. Meema, Y. Tachikawa. Structural improvement of a kinematic wave-based distributed hydrologic model to estimate long-term river discharge in a tropical climate basin. Hydrol. Res. Lett., 14 (2020), pp. 104-110, 10.3178/hrl.14.104

Real-time forecast scheme

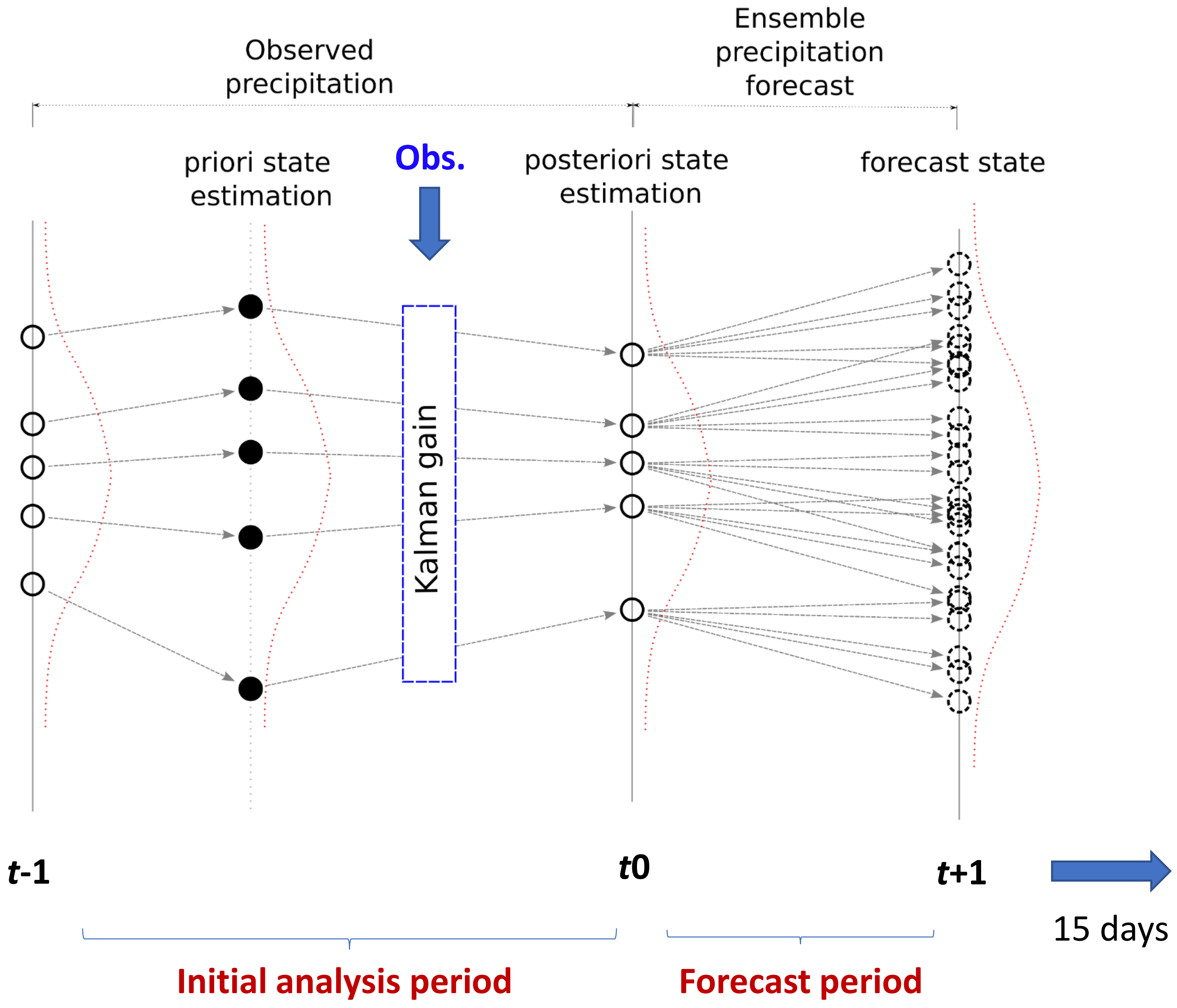
- For **real-time forecast**, the model **was updated the state variables** regarding the current **observation** during the **initial analysis period** (until ***t*0**) **before performing the forecast** (forecast period) using observed rainfall.
- The **model state variables** at ***t*0** (**initial forecast time**) were used as **model initial condition** of the **forecast period**.
- The **ensemble flood forecasting** was performed **using EPF** as **forcing data**.



Ensemble Kalman Filter (EnKF)

Flood forecast scheme at time *t0* to lead time *t*+1

- Incorporate **Ensemble Precipitation Forecast** (EPF) information with **Ensemble Kalman Filter** (EnKF) technique.
- EnKF is adopted **to determine model states** at time ***t0*** (initial conditions) using observed precipitation.
- The forecast period was **performed without assimilation** from time ***t0*** until the proposed lead time **using EPF**.



Sensitivity analysis of DA approaches

- **Sensitivity analysis of DA** was performed **to select the DA parameters** for the study basin.
- The **tropical storm events** in 2016 (Dianmu), 2017 (Talas) and 2018 (Bebinca) **were selected for sensitivity analysis**.
- For sensitivity analysis of DA approaches, **obs. Rainfall** was applied considering **as a perfect rainfall forecast** in the forecast period.

Experimental setup of EnKF

Member (*n*)	Observation Noise (ε_{obs})	System Noise(ε_{state})	Spatial Correlation (λ, km)
16	0.05	0.05 0.2 0.3	NA 1 5 25

Noise Model

- System Noise

$$\omega_i \sim N(0, (\varepsilon_{state} \times Q_{state})^2)$$

- Observation Noise

$$v_i \sim N(0, (\varepsilon_{obs} \times Q_{obs})^2)$$

Spatial correlation

distance between grids *i* and *obs. grid*

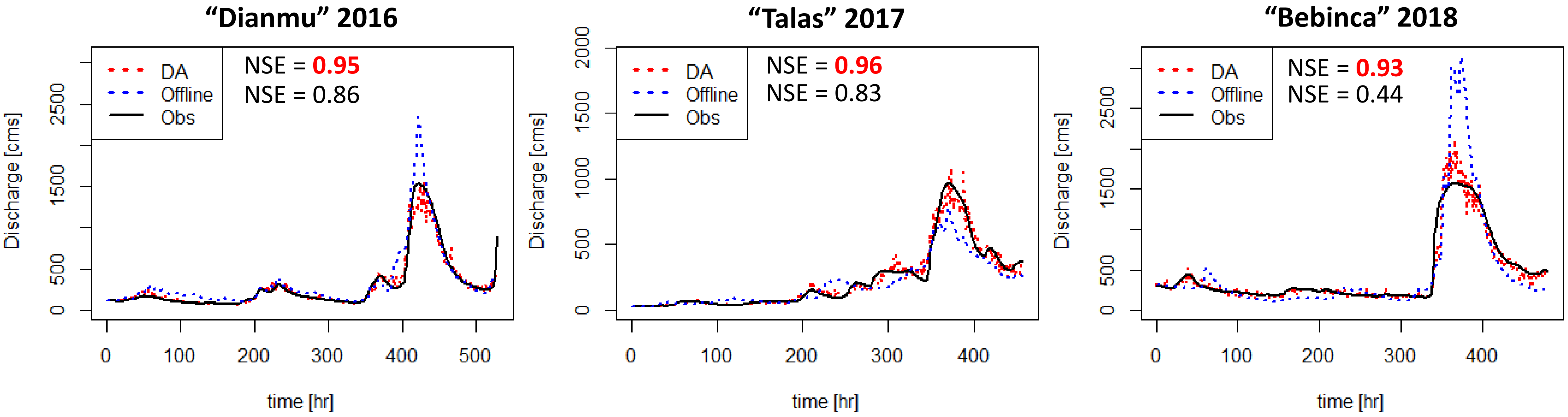
$$e^{-\frac{l_{ij}}{\lambda}}$$

correlation distance

The parameters of ε_{obs} = 0.05, ε_{state} = 0.3 and λ = 5 km resulted in minimum error (RMSE) in forecast result during the Sensitivity analysis period.

Analysis DA approach

1 hour ahead of forecasting discharge at N.1



Incorporating EnKF with the DHM resulted in a better streamflow prediction than offline simulation.

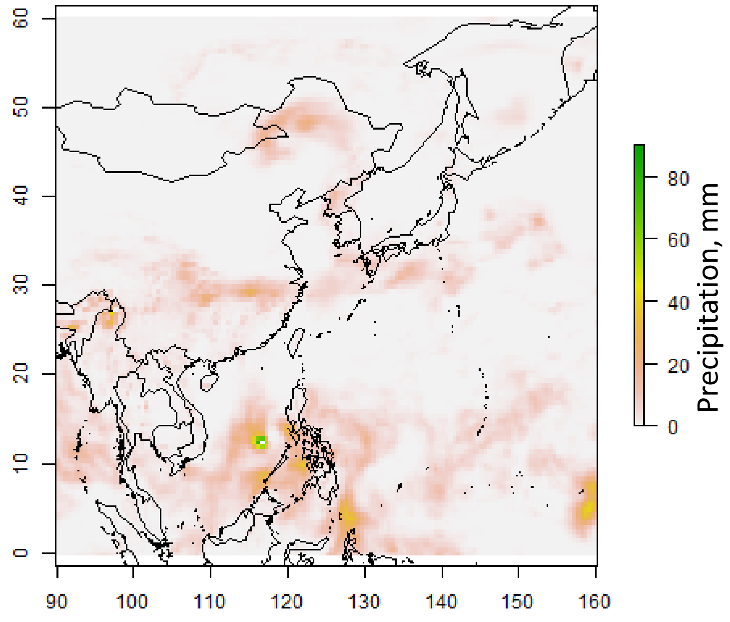
Real-world application: A case study of the tropical storm “Sinlaku” in 2020

Ensemble Precipitation Forecast (EPF)

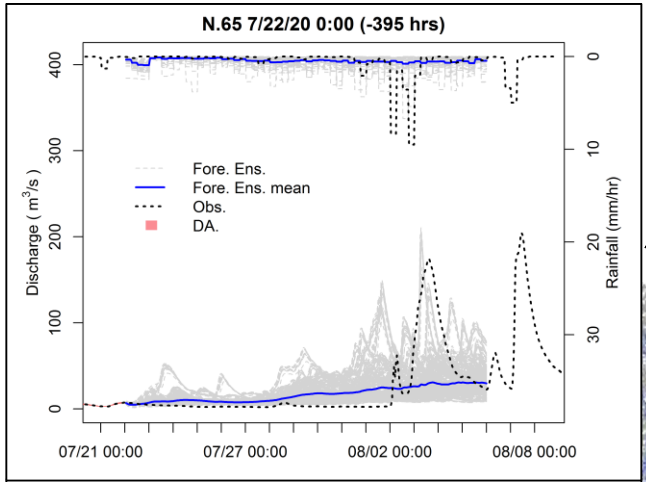
ECMWF (European Centre for Medium-Range Weather Forecasts)

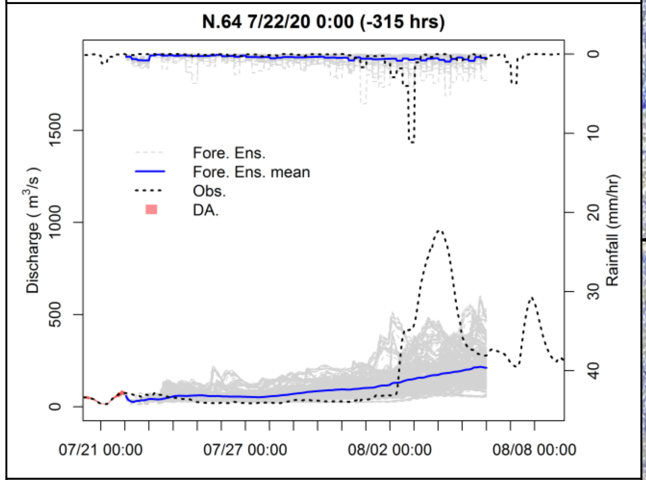
- **51** members
- Approximately **0.5** degree resolution
- Forecast of **15** days
- **6** hours of temporal resolution

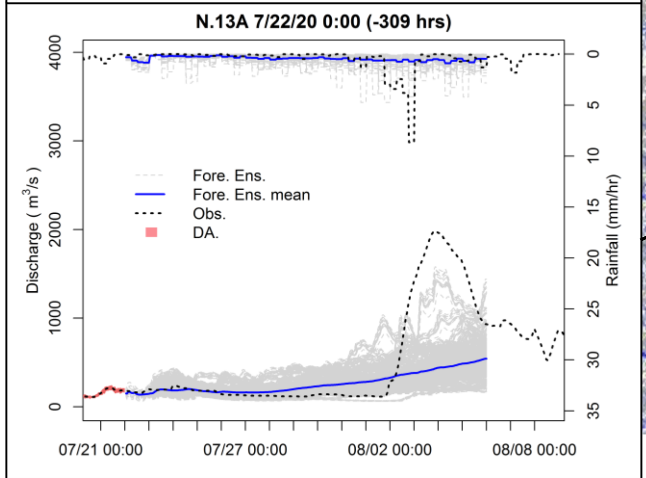
Medium-Range Precipitation Forecast, mean of ensemble
Lead time 6 hour



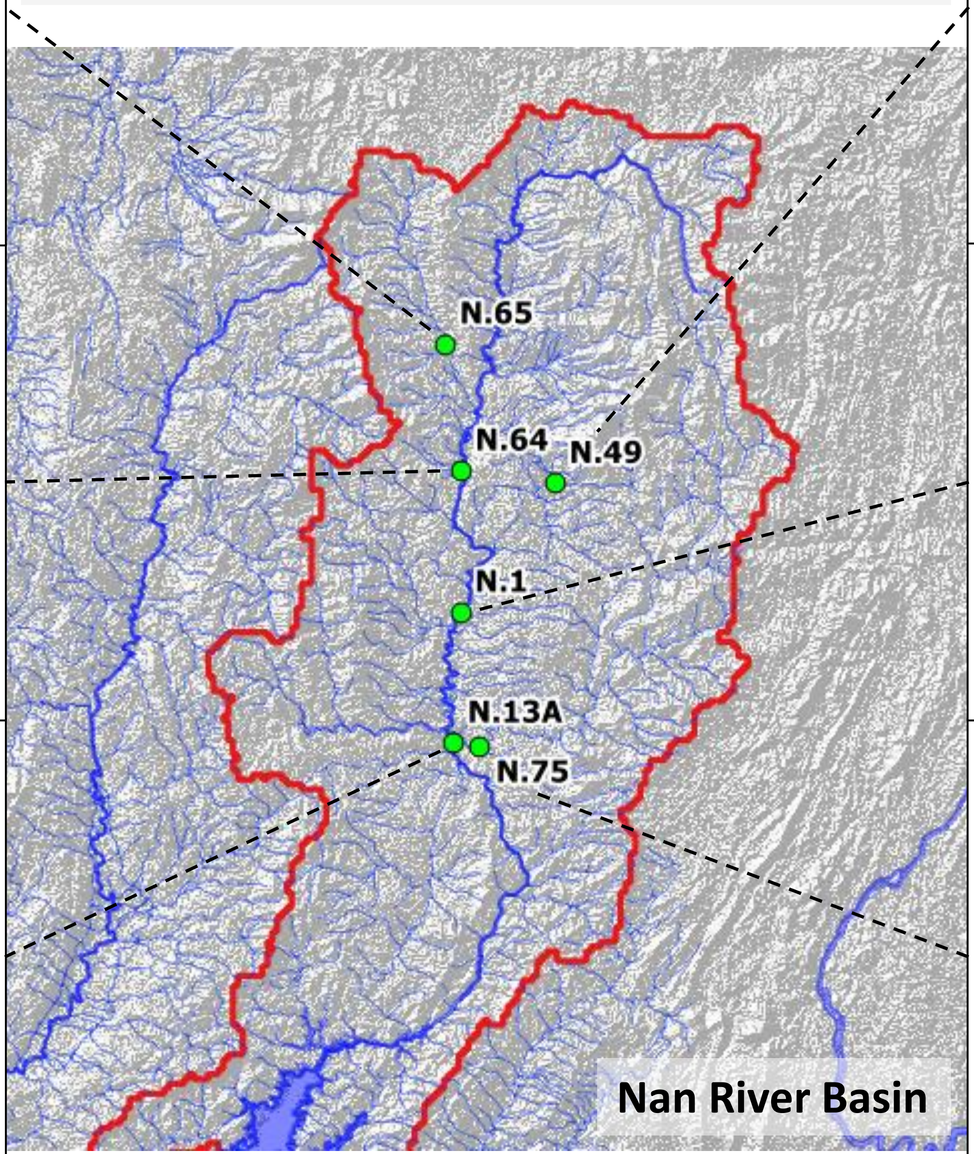
Initial forecast time 2020-09-16 00UTC

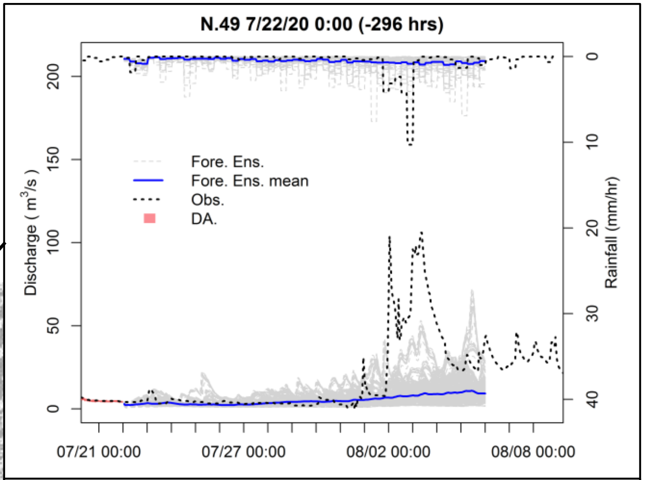


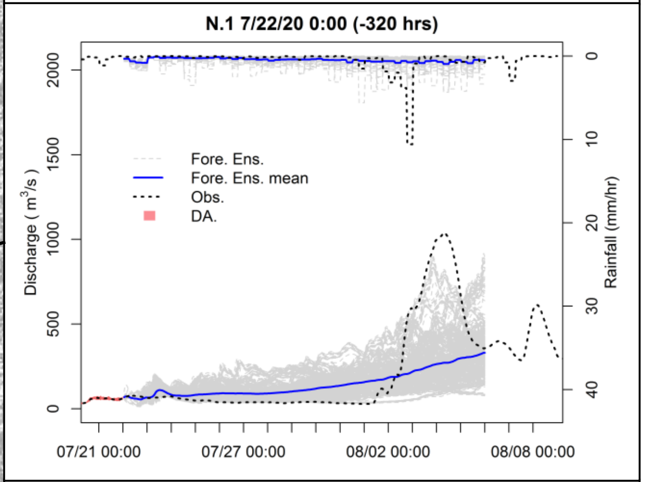


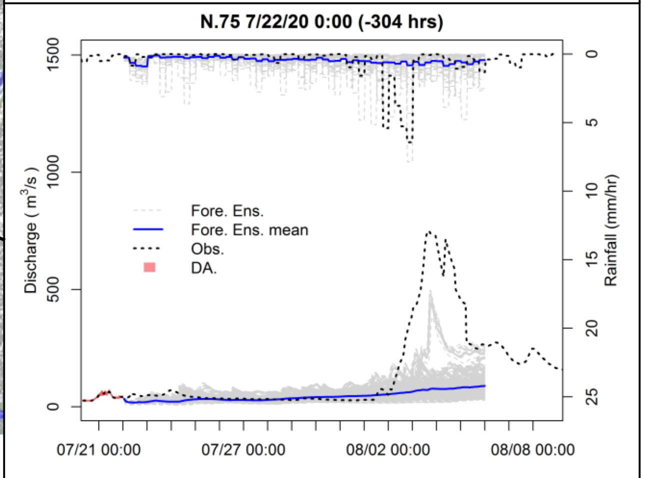


Real-time Forecasting start performing ~ 12days before the tropical storm “Sinlaku” in 2020

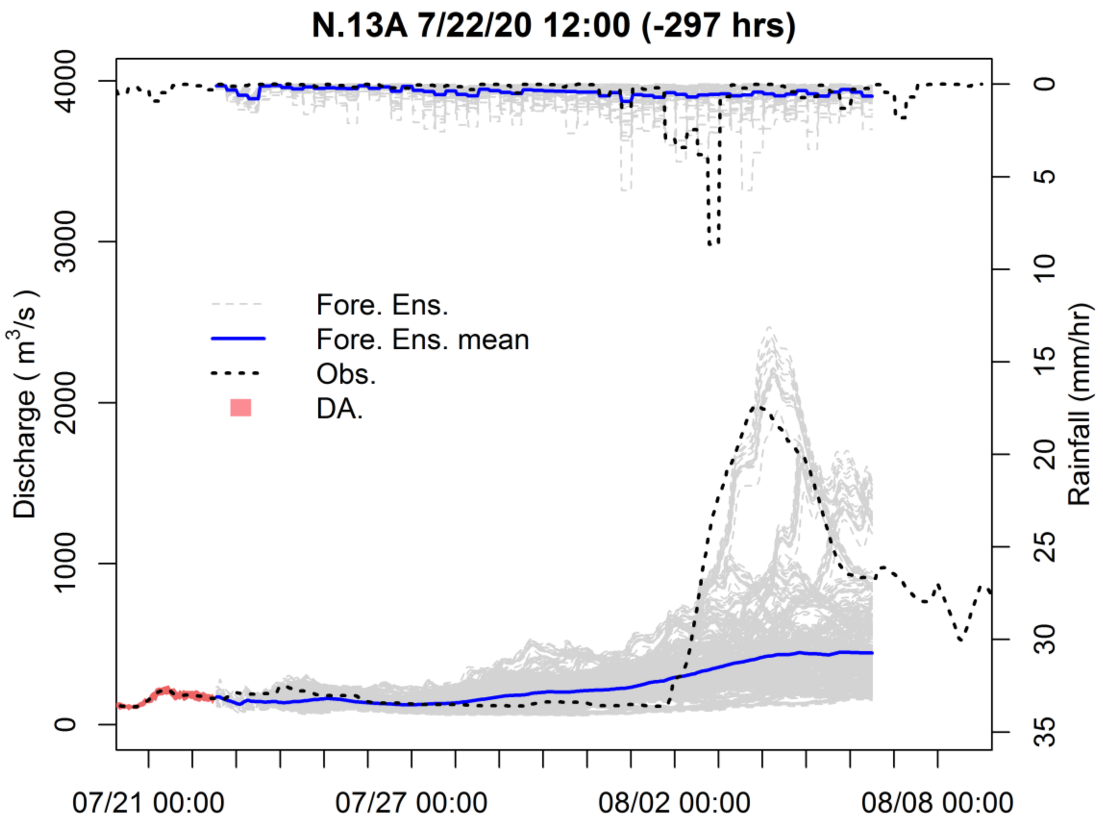




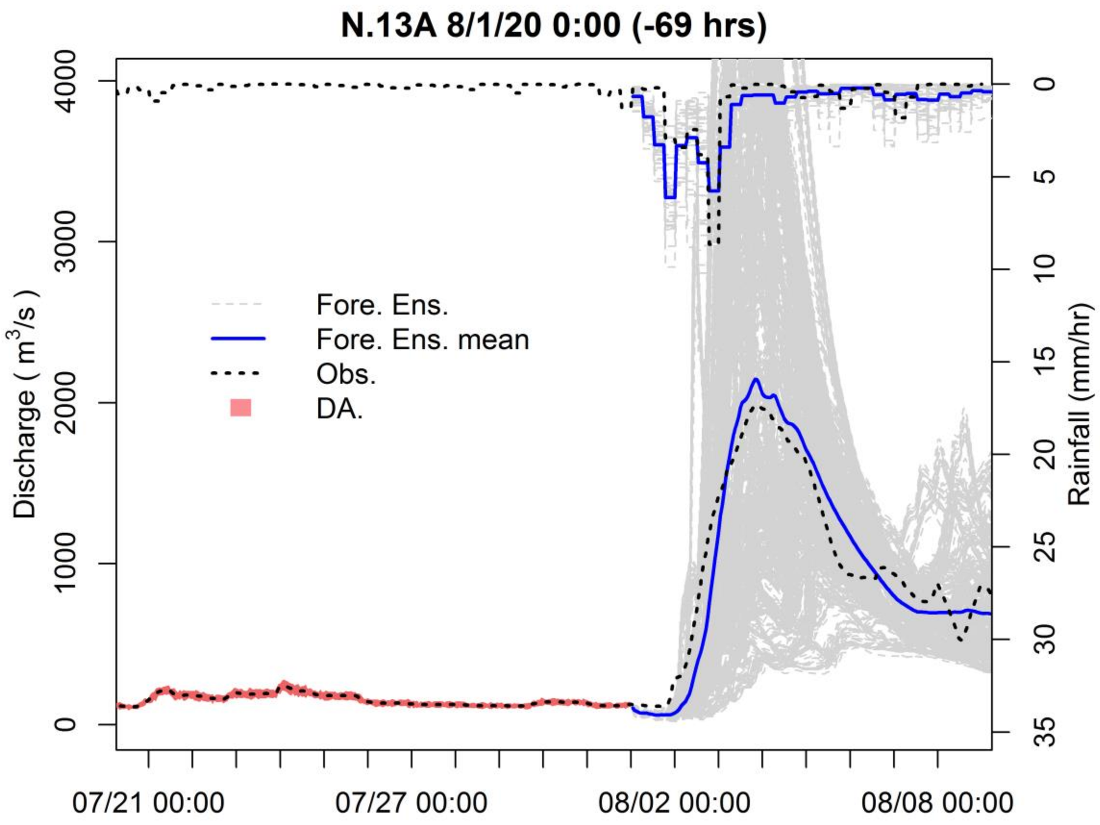




Forecasting results (at N.13A)

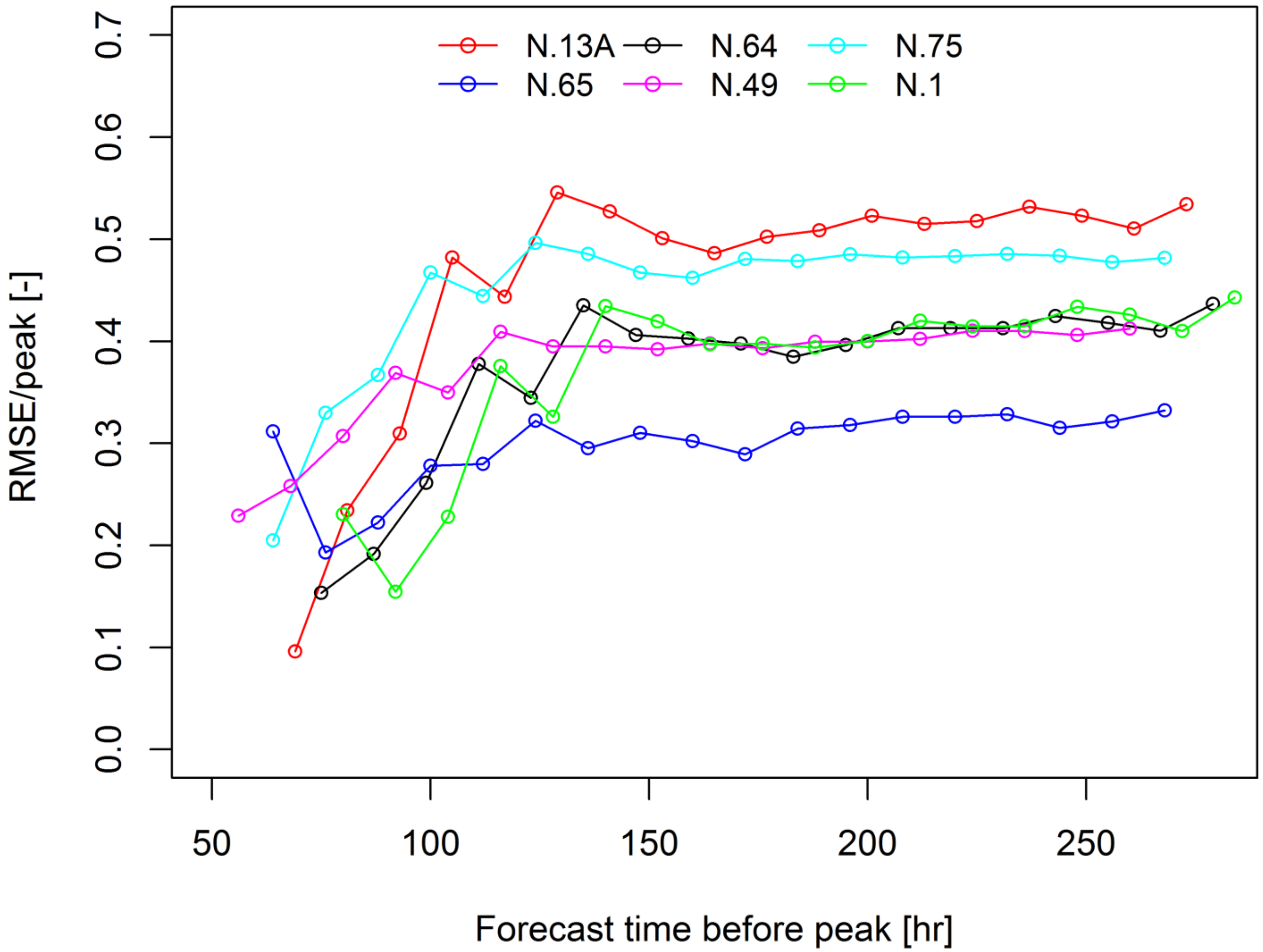


Some forecast members present the possibility of flood since a long-lead-time (>12 days).



The mean of forecast members could capture the flood hydrograph approximately 3 days in advance.

Forecast performance



- The **forecast error** **tends to decrease** when the forecast lead time decreases.
- Because of the **increase** **in the accuracy** of precipitation forecasts.

Conclusions (1)

- Using the DHM, there is an **advantage in the spatial distribution of forecast outputs** (at any river section can be forecasted).
- By using the scheme for this study, the mean of forecast members **could capture the flood hydrograph** approximately 2-3 days in advance.
- This could **provide timely hazard information** as an **advantage in a long-lead-time forecast**.

Conclusions (2)

- Coupling EnKF and EPF for real-time forecast, there is a **disadvantage in simulation cost**.
- This requires the **high performance of computation resources**.
- The scheme **requires an accurate precipitation forecast**.
- The scheme needs to verify **with further events**.

Thank you for your kind attention..