Ensemble Kalman Filtering with perturbed rainfall for improving flush flood predictions by a Rainfall-Runoff-Inundation Model

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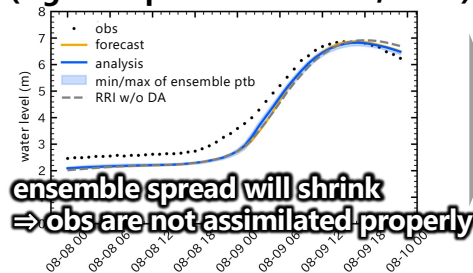*Environmental Prediction Science Laboratory*

Background and Objective

Objective: Assimilate simulated water levels with EnKF to improve forecast accuracy
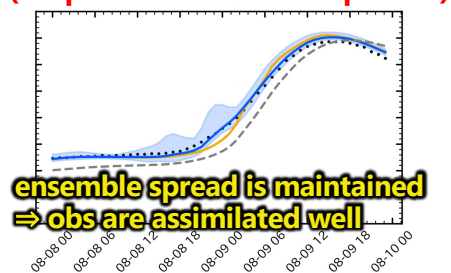
What is the appropriate covariance inflation method when applying EnKF to a non-chaotic hydrological model?

- The output of RRI being more influenced by the current rainfall, rather than the initial state

**with typical inflations (e.g. multiplicative inflation, RTPP)**

- obs
- forecast
- analysis
- min/max of ensemble ptb
- RRI w/o DA

water level (m)

ensemble spread will shrink ⇒ obs are not assimilated properly

with proposed inflations (i.e. perturb to rainfall & params)

ensemble spread is maintained ⇒ obs are assimilated well

Rainfall-Runoff-Inundation (RRI) Model

Two-dimensional model capable of simulating rainfall-runoff and flood inundation simultaneously

rainfall → RRI model → water level / discharge

Sayama et al. (2012)
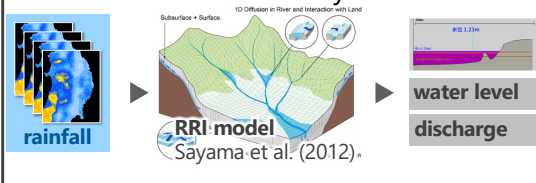
Method & Experiment Settings

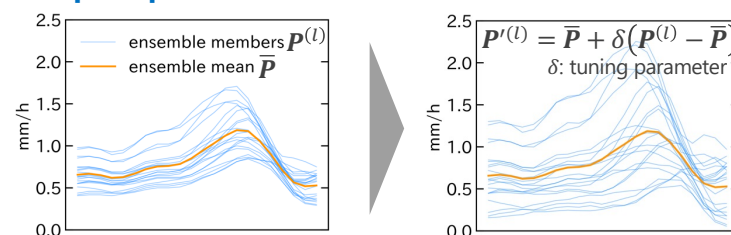**Expand the spread of RRI output by adding per-ensemble uncertainty to the model**

① Perturb to rainfall
Using ensemble forecast rainfall distribution
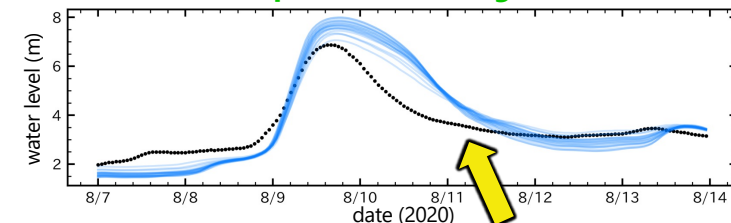- Meso-scale ensemble prediction system (MEPS)

② Perturb to model parameter
- Manning's roughness coefficient (flow velocity)
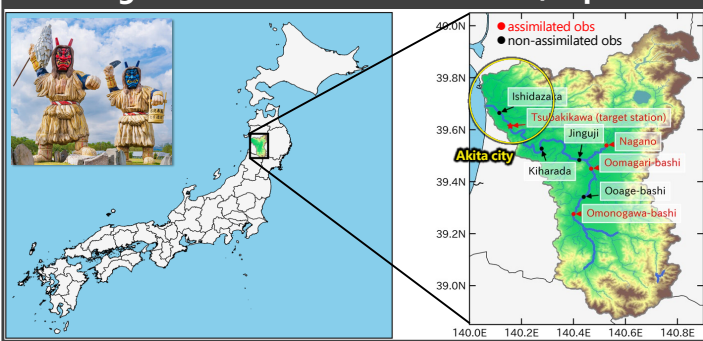- Effective porosity (infiltration into the ground)

Target Basin: Omono River in Akita, Japan

- assimilated obs
- non-assimilated obs

Ishidazaka
Tsubakikawa (target station)
Jinguji
Nagano
Oomagari-bashi
Kiharada
Akita city
Ooage-bashi
Omonogawa-bashi

① Expand perturbation of ensemble forecast rainfall

- ensemble members $P^{(l)}$
- ensemble mean $\overline{P}$

mm/h

$$P'^{(l)} = \overline{P} + \delta(P^{(l)} - \overline{P})$$
δ: tuning parameter

② Perturb to model parameters change simulated results

water level (m)

date (2020)

Ensemble spreads can be maintain even with the same initial conditions & rainfall inputs

Experiment Settings
- Serial EnSRF (21 members)
- Assimilate hourly obs at 4 stations

Result: 9hr Forecast Simulation

analysis

DA cycle w/ real obs
time
forecast w/ MEPS

- obs
- w/ DA
- w/o DA

water level (m)

improved by DA

day of Aug, 2020
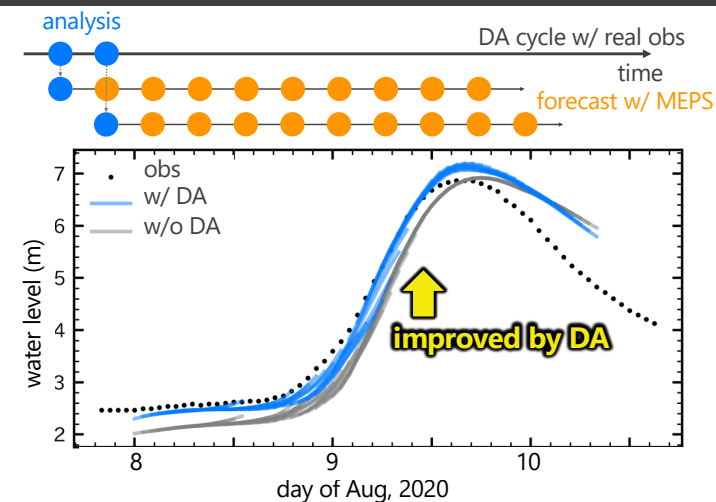
Summary

What we did

- We applied EnKF for RRI to adjust model state variables with operational water-level observations.
- The assimilation was stabilized by perturbing the input rainfall intensity and model soil parameters for each ensemble member.
- Our experiments showed that predicted water level was improved at both observed and unobserved stations compared to the RRI simulations without assimilation.

Future work

- To find the optimal parameter combinations for the inflation methods proposed in this study.