Ensemble Data Assimilation of Water Quality Variables

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Algal bloom outbreaks

❖ Cyanobacteria bloom outbreaks in major rivers and lakes have been important environmental issues in Korea

Photo: www.ohmynews.com

Algal bloom outbreaks

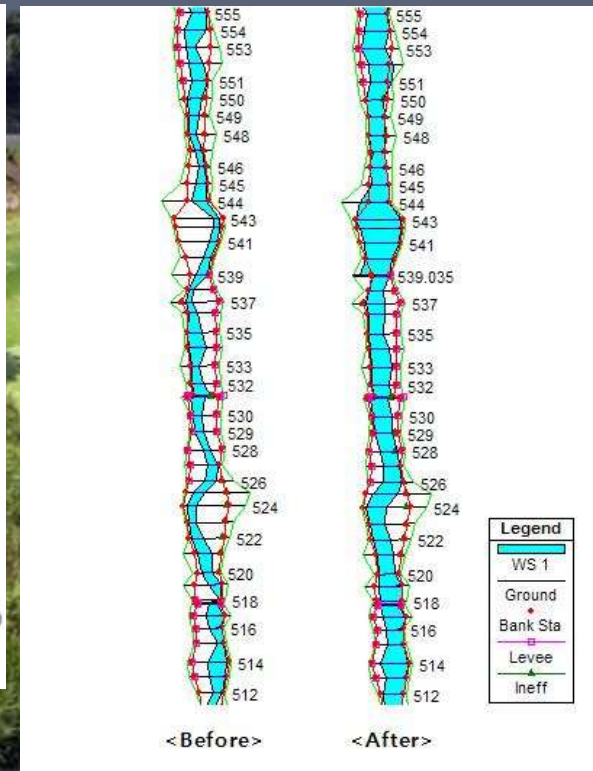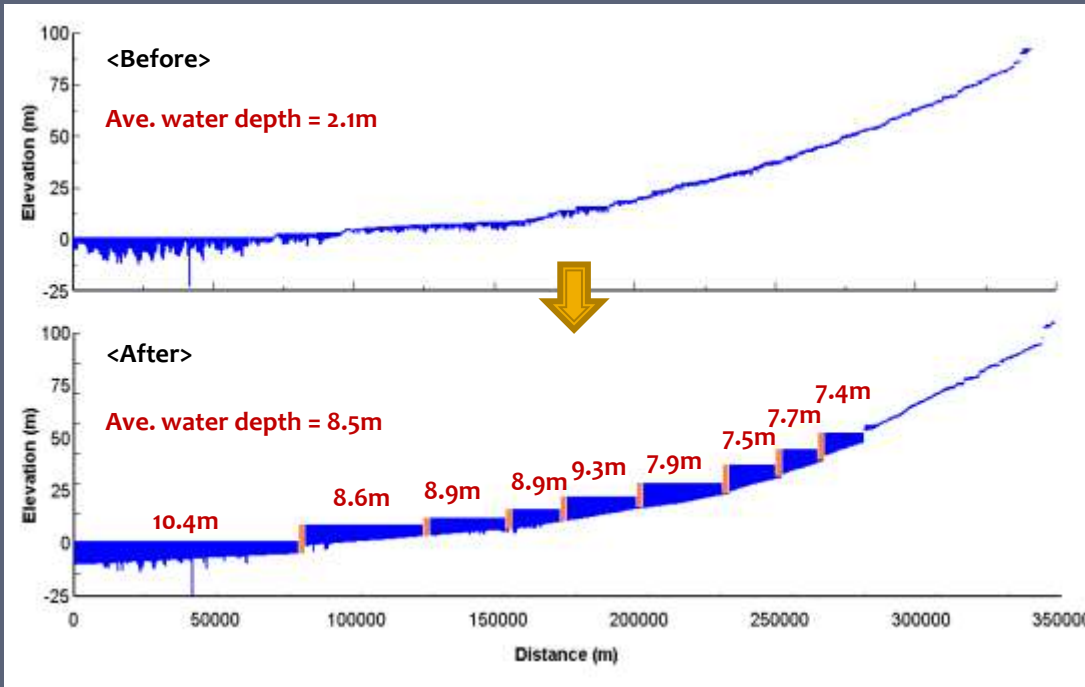❖ Cyanobacteria bloom outbreaks in major rivers and lakes have been important environmental issues in Korea


Photo: www.ohmynews.com

Effort of WQ degradation prevention

❖ Flushing-out is one of active measures to respond major cyanobacteria blooms
 − As an example, abrupt increase of discharge from Choongju dam was made to flush out cyanobacteria bloom in Lake Paldang (summer 2012)
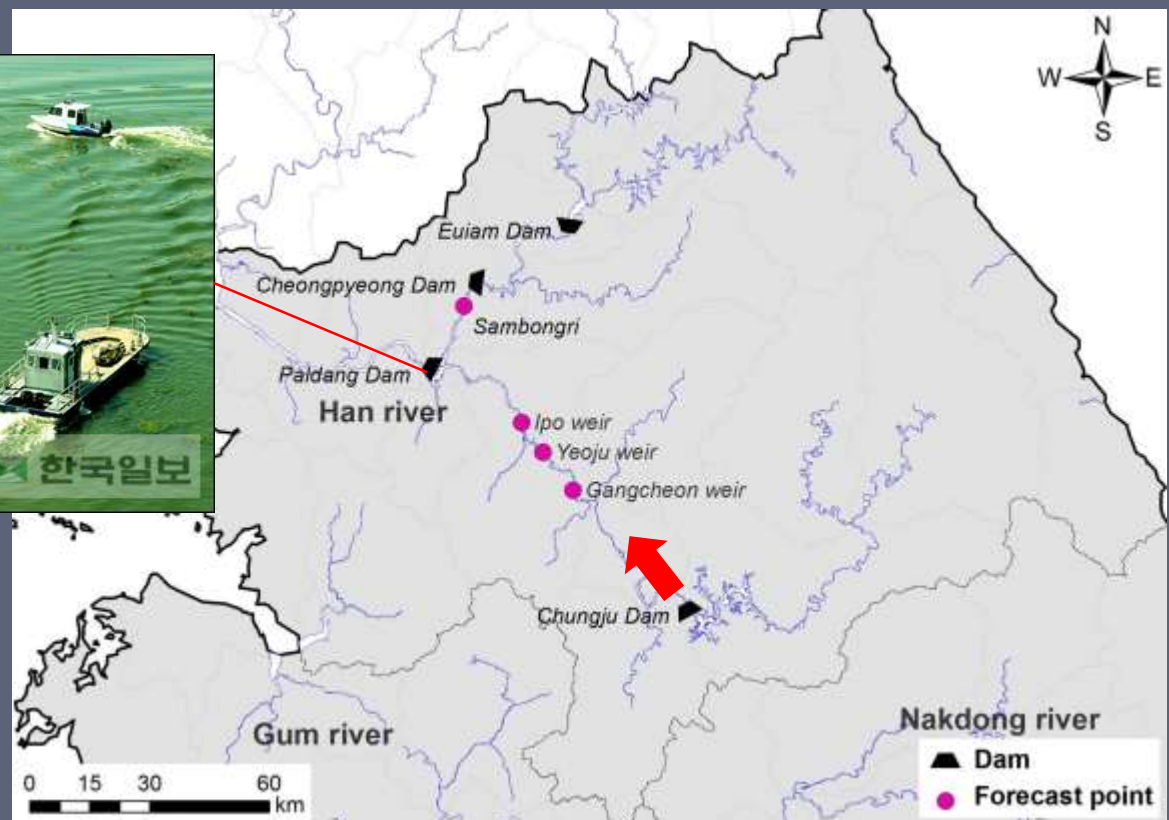
Efforts of WQ degradation prevention

❖ Various scenarios were simulated to determine amount and duration of discharge and actual release was made based on one selected scenario
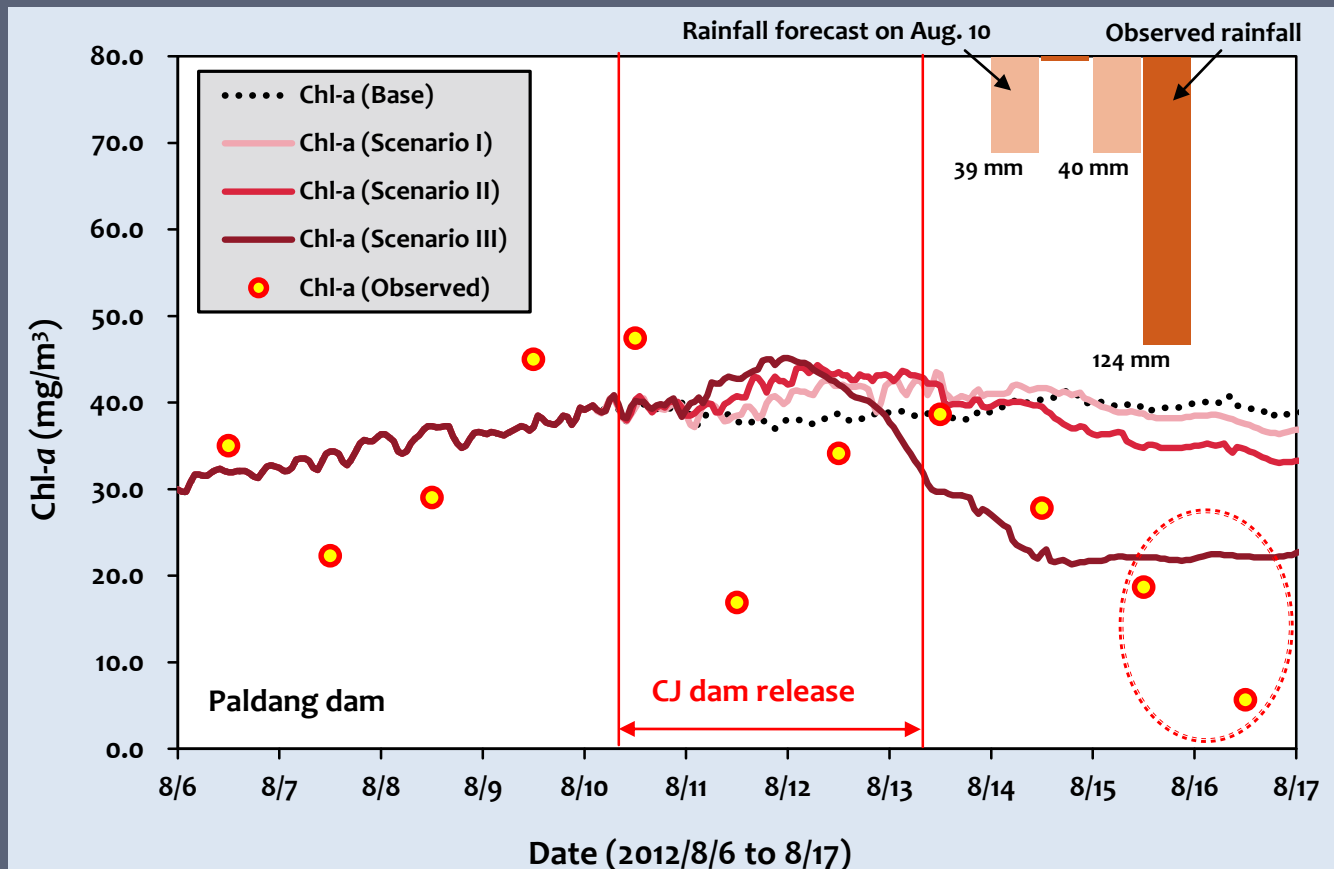
Algal bloom forecast

❖ Since January 2012, NIER has been producing 7-days algal bloom forecast for the 16 weir locations in the major rivers in Korea

– **Forecasting variables**:
  water temp. and **Chlorophyll-*a* level**
  - It will be extended to other WQ
  variables in the future (e.g., TOC & SS)

– **Forecasting model**:
  a **HSPF-EFDC coupled model** developed
  for the four watersheds

– **Forecasting report**: A 7-days WQ forecast
– **are officially announced on every Monday**
  and Thursday and circulated to water
  management agencies in the Han River
  basin via a dedicated website.
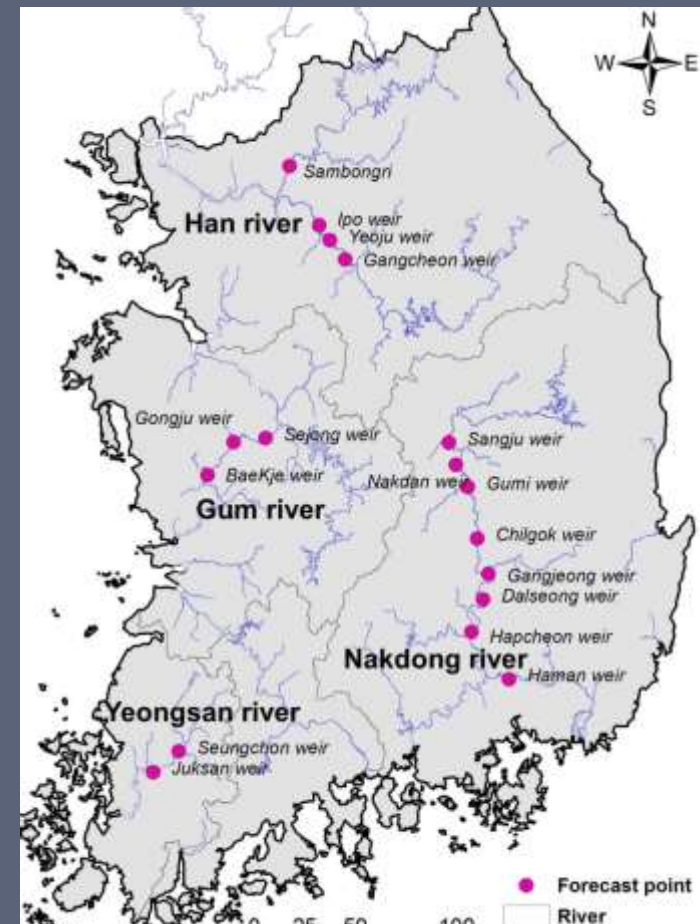
A summary of the first two years forecast

❖ The RMSE of water temperature forecast for each location tends to increase with lead time but not significantly
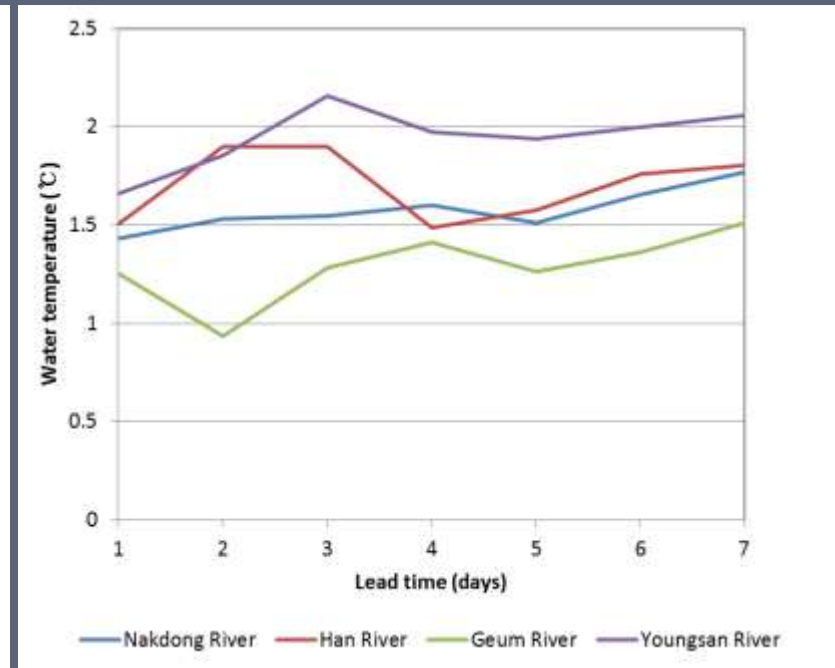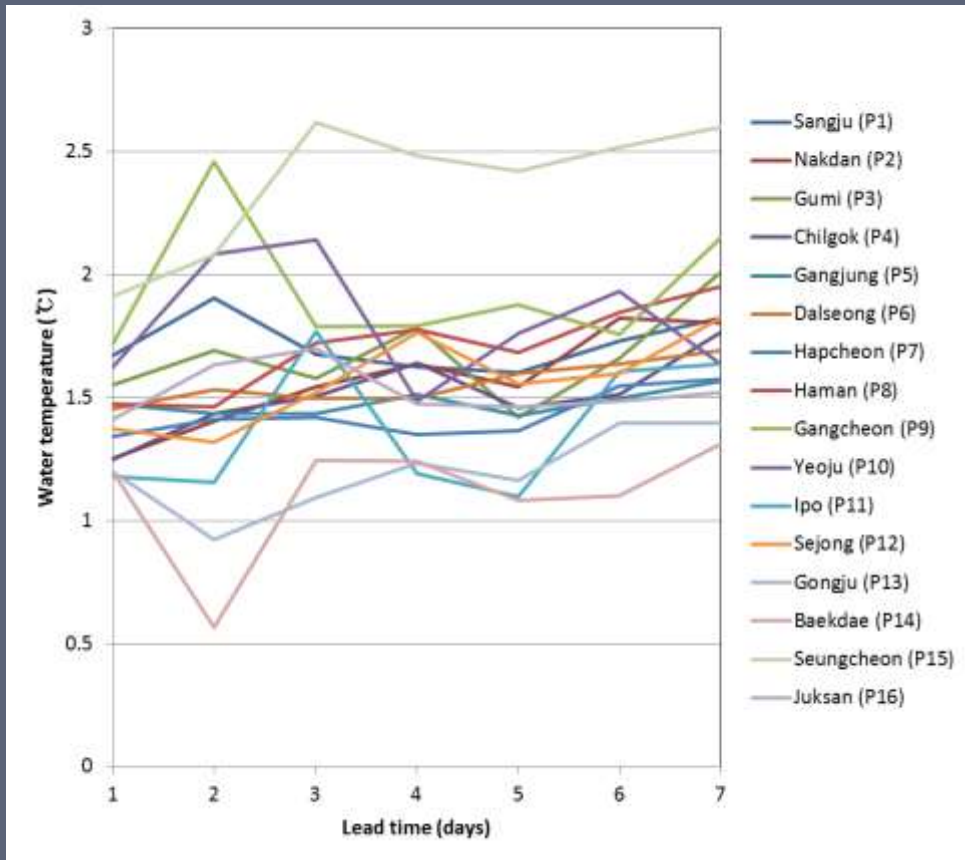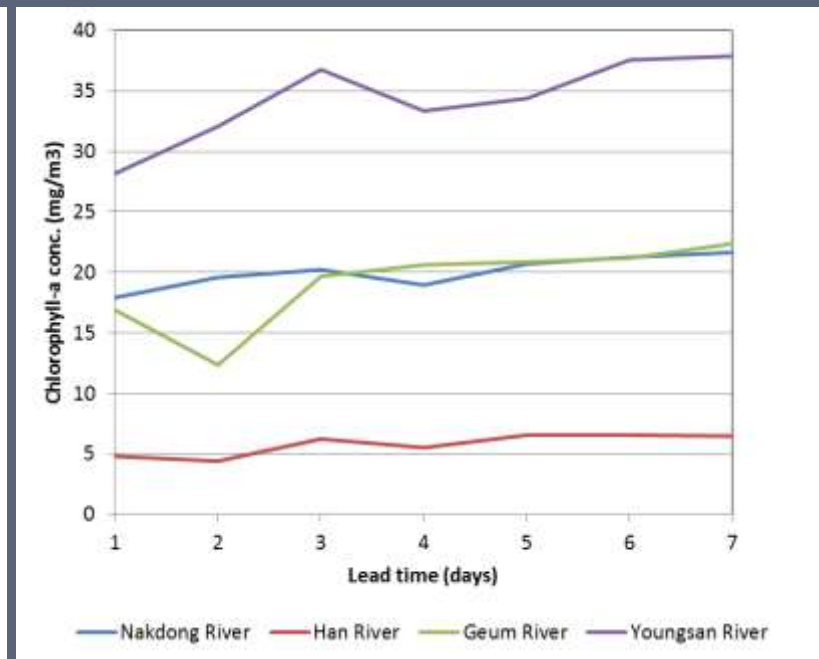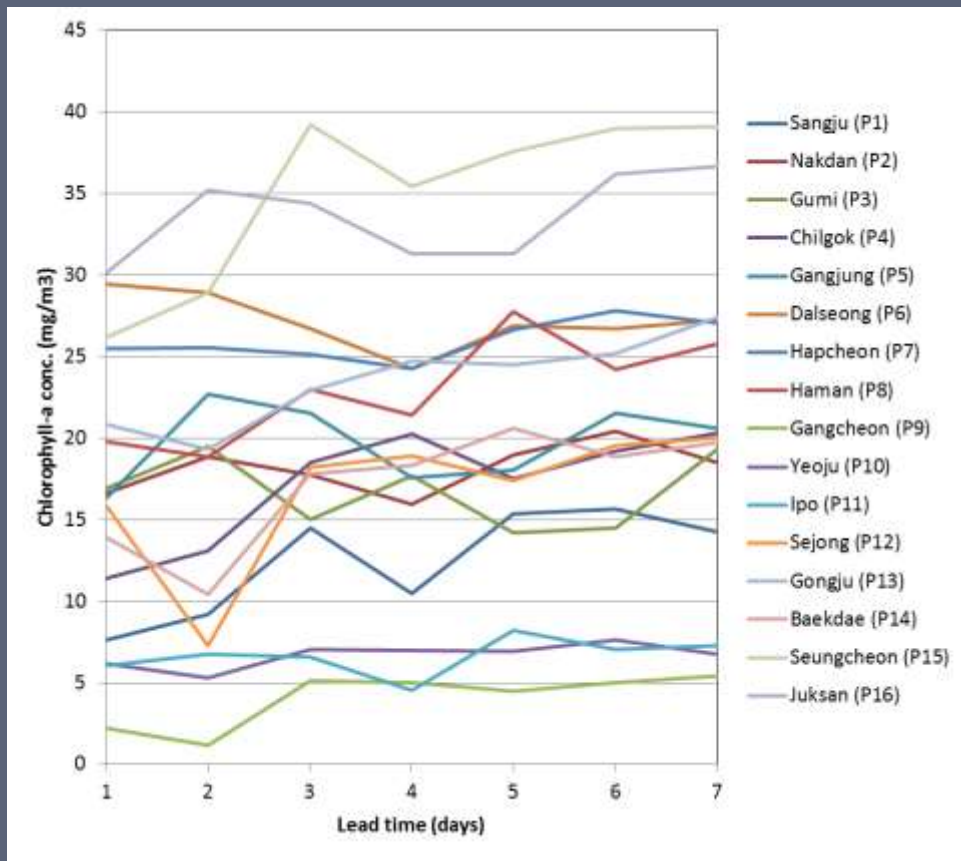

▲ Variation of the mean RMSE for each river with lead time

◄ Variation of RMSE for each location with lead time

A summary of the first two years forecast

❖ The RMSE of chlorophyll-a forecast for each location tends to increase with lead time but not significantly

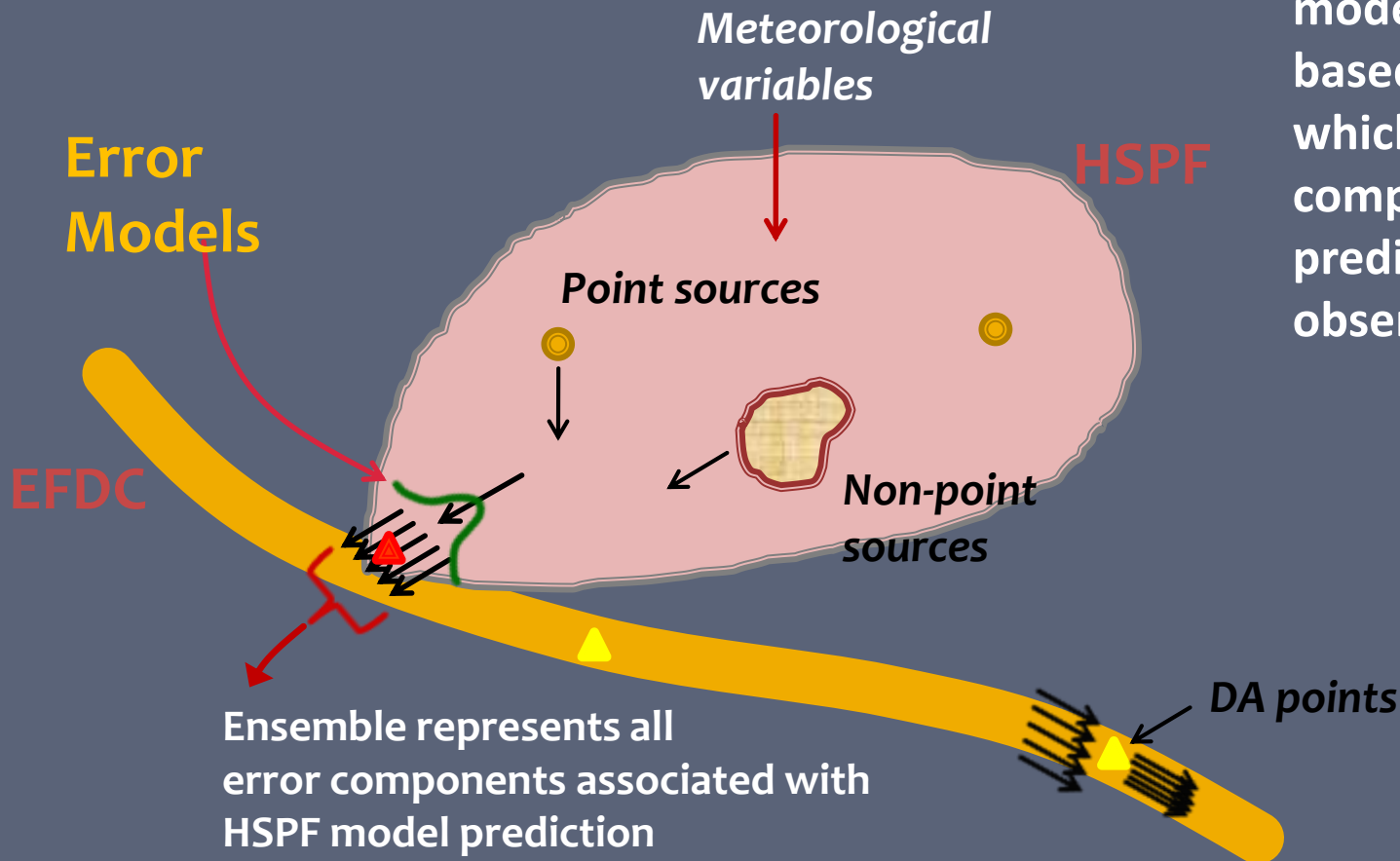▲ Variation of the mean RMSE for each river with lead time

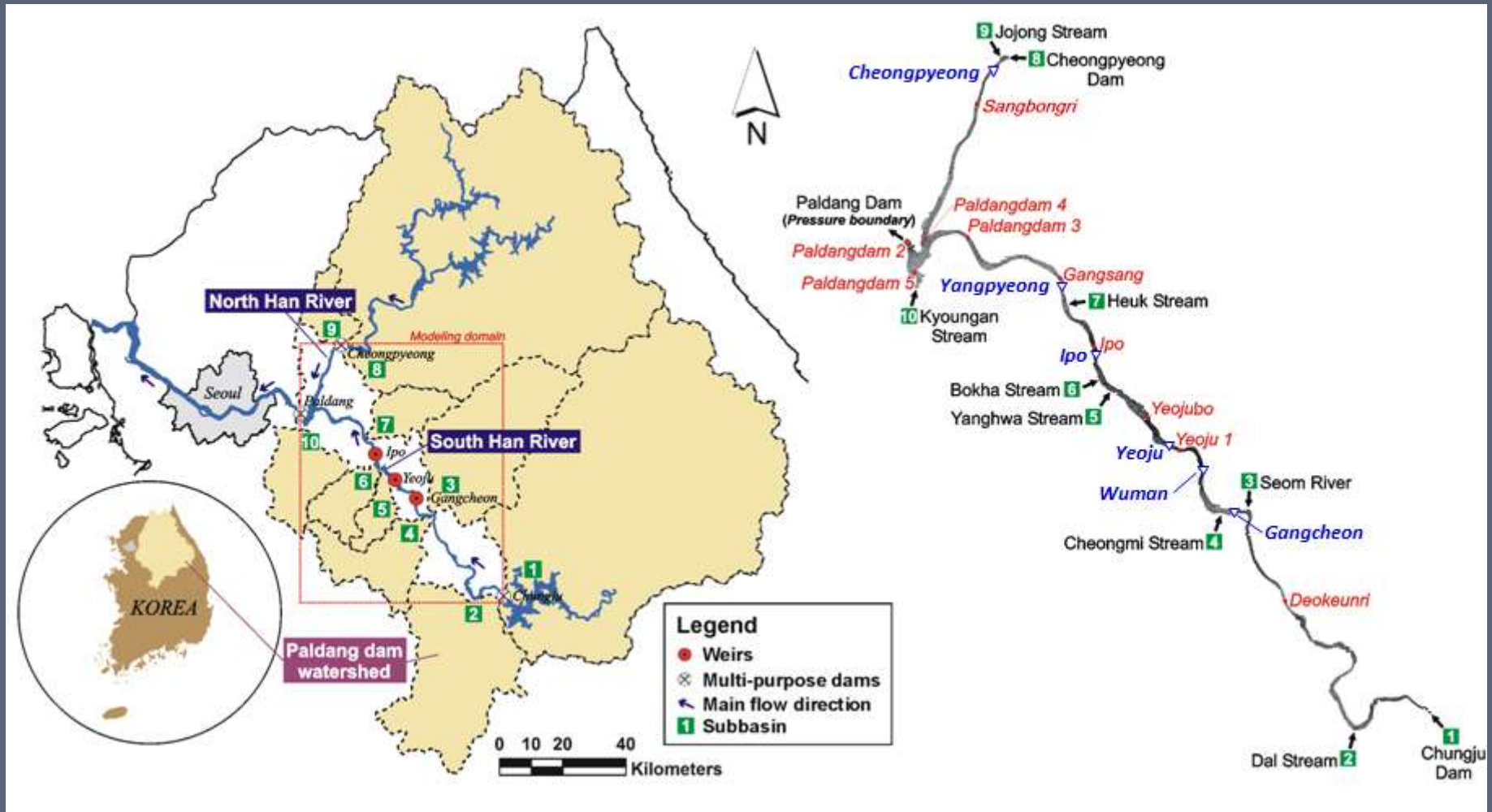◄ Variation of RMSE for each location with lead time

Reducing Forecast Error : Data assimilation

## *Ensemble Kalman Filter for EFDC model*

❖ **Ensemble representation of EFDC model prediction is created by applying perturbation to HSPF model prediction based on error models, which are built by comparing model prediction and observation**

Error Models

HSPF

Meteorological variables

Point sources

Non-point sources

EFDC

Ensemble represents all error components associated with HSPF model prediction
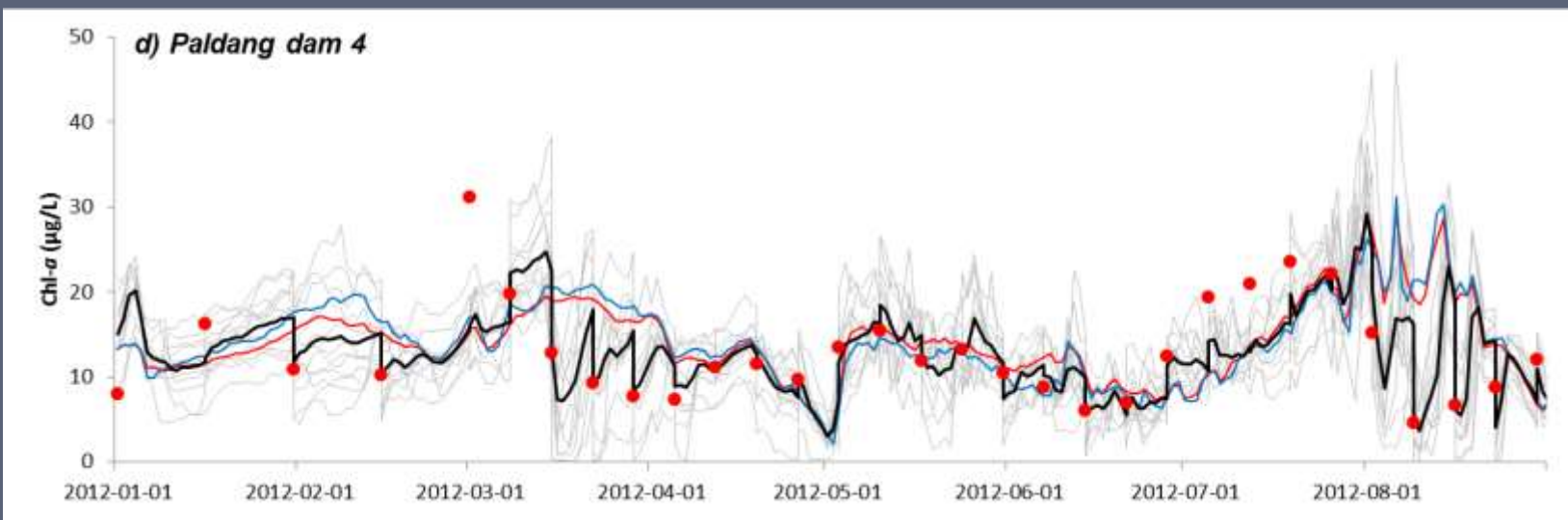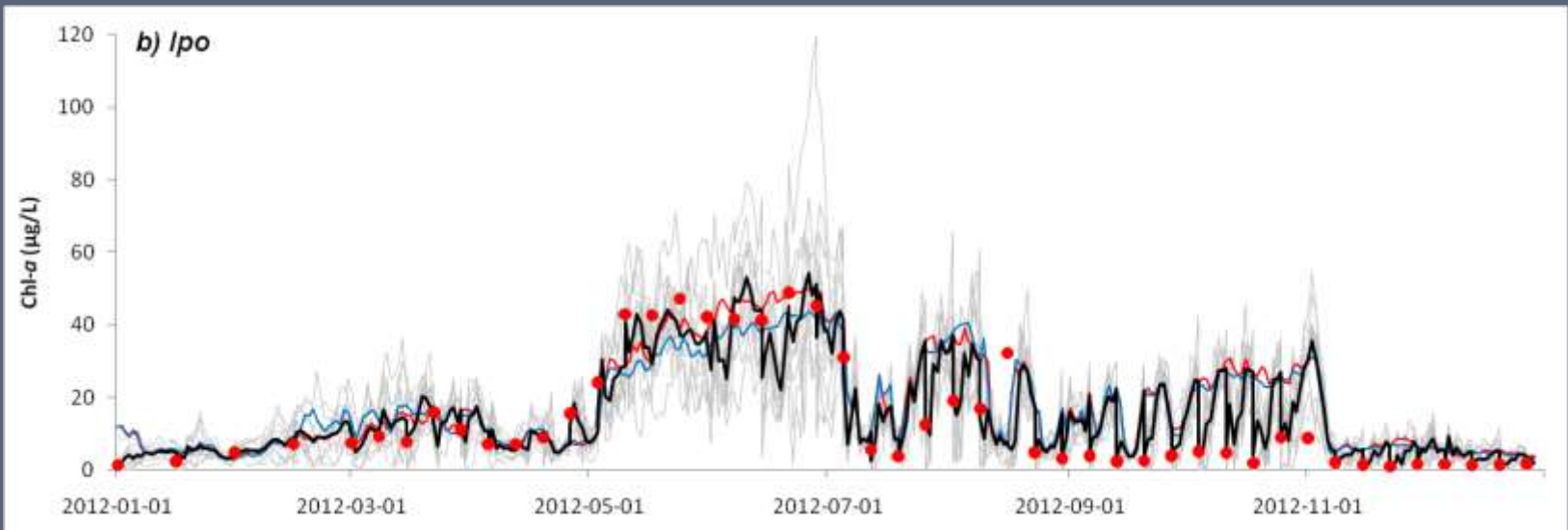
DA points

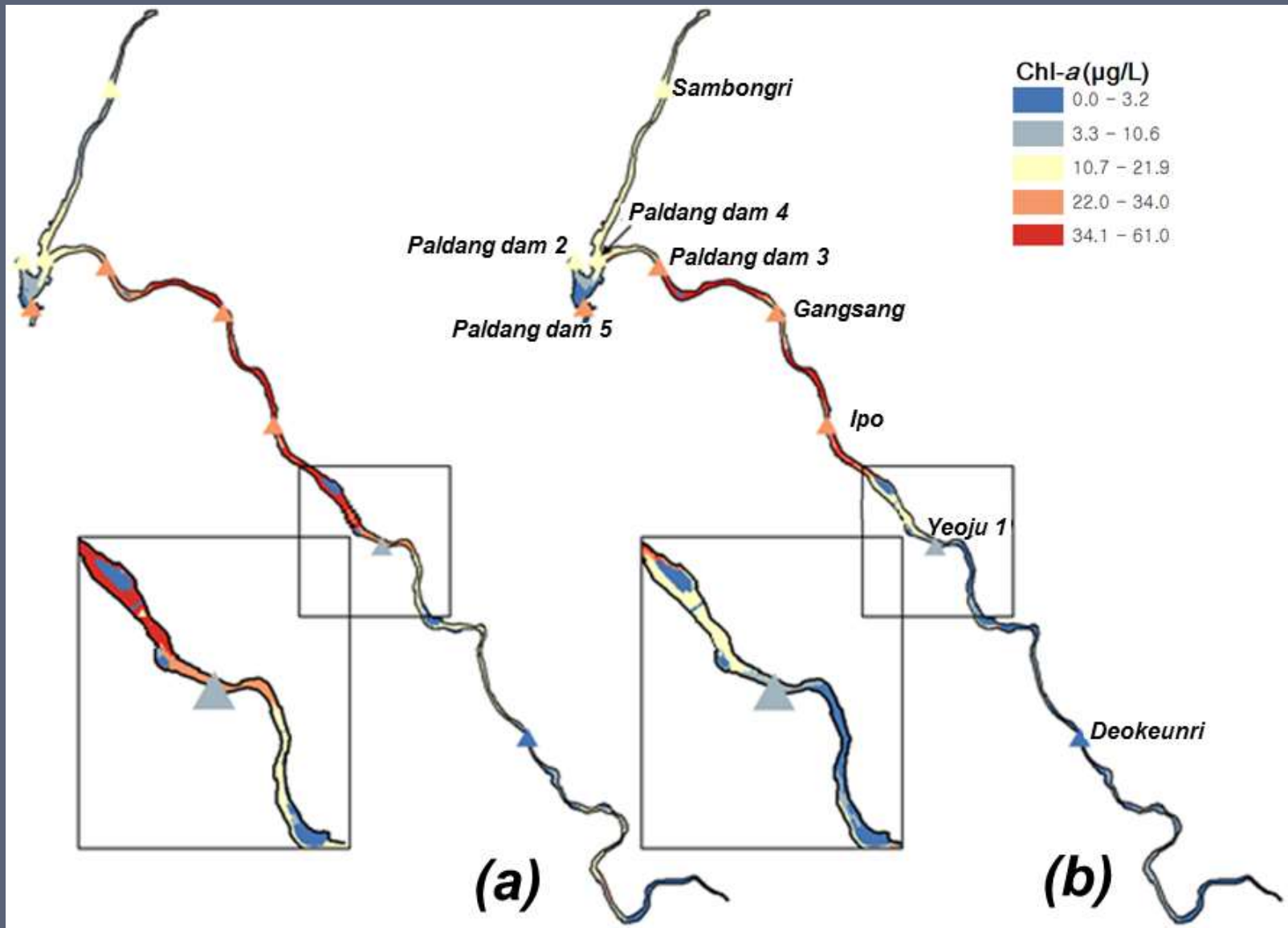# Study site - Han River watershed

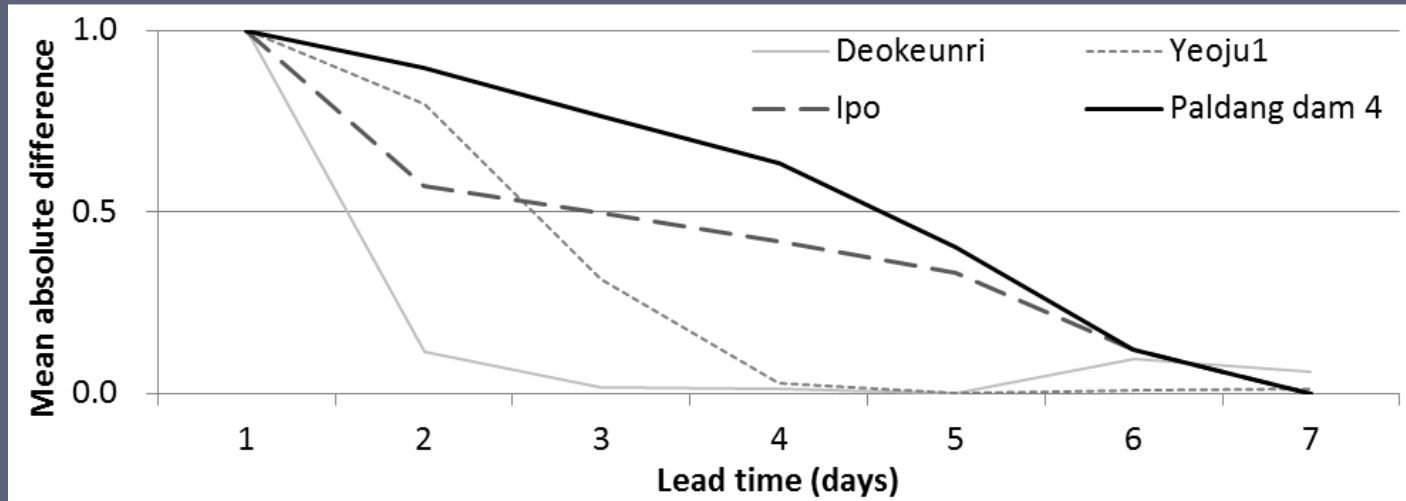# Results of Chl-a ensemble simulation with DA
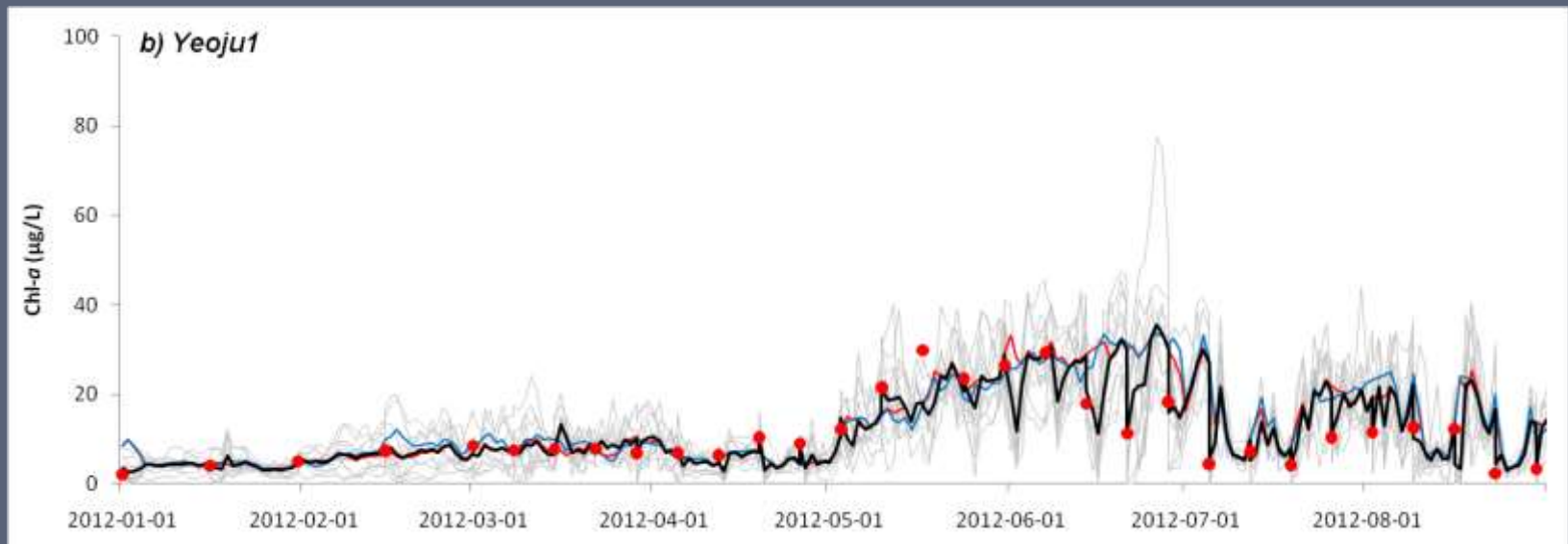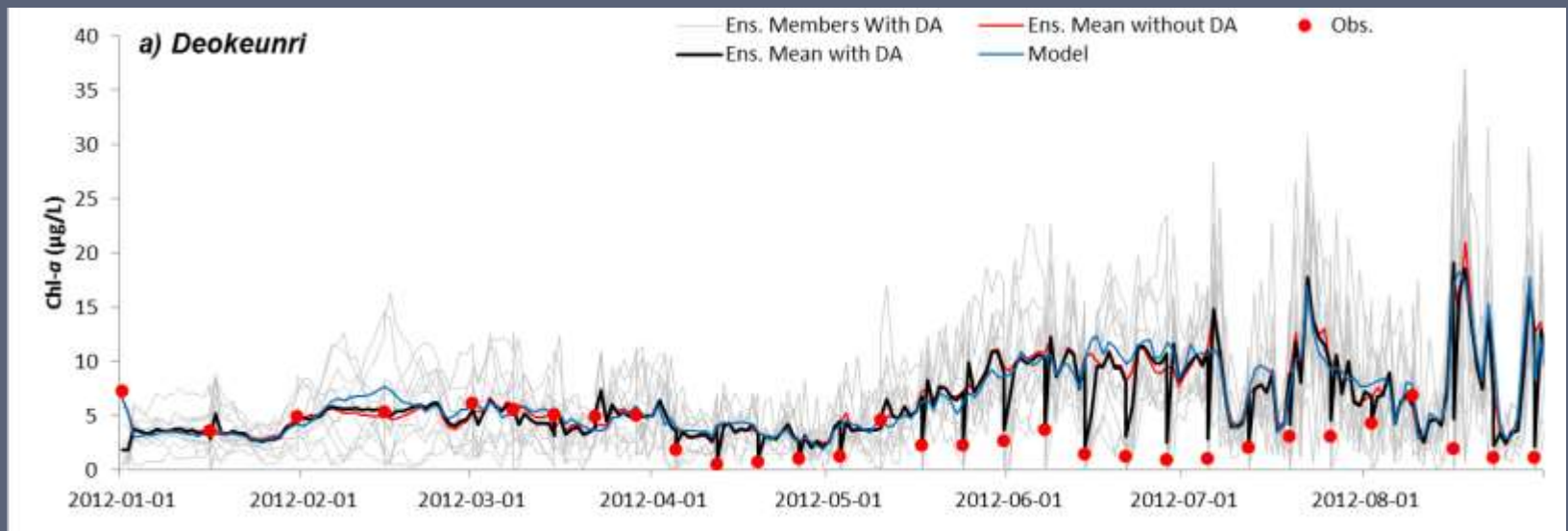
Results of Chl-a ensemble simulation with DA

Results of Chl-a ensemble simulation with DA

How fast does the effect of DA disappear?
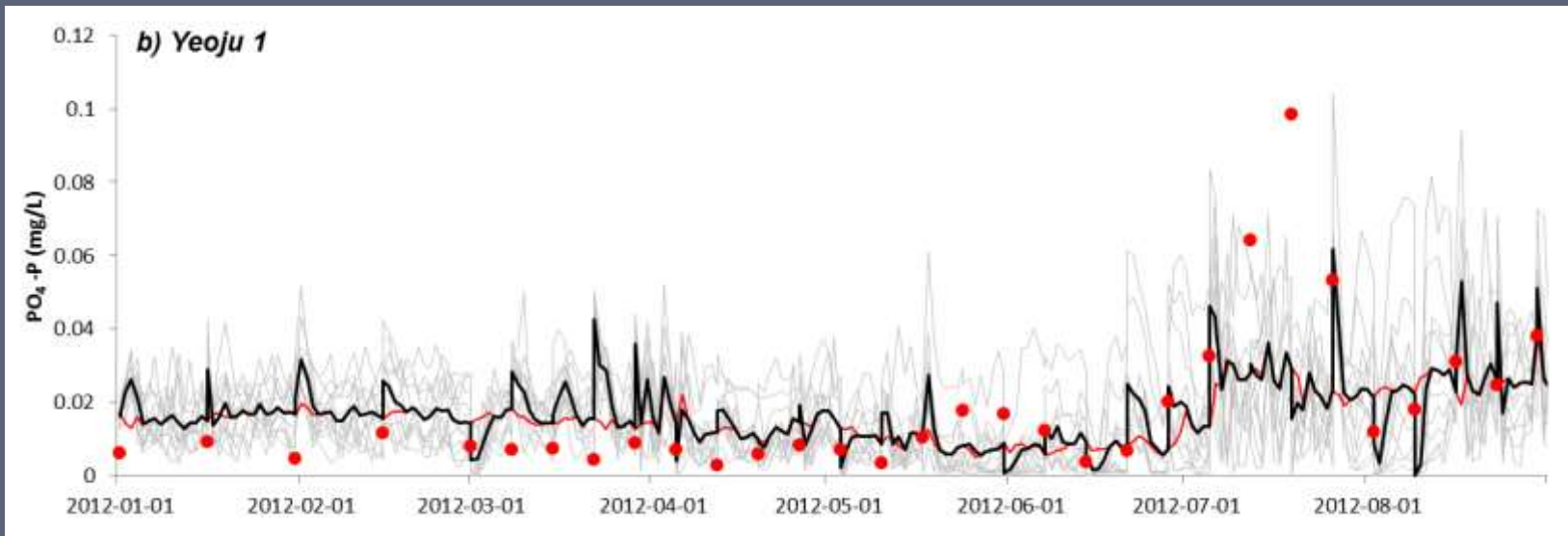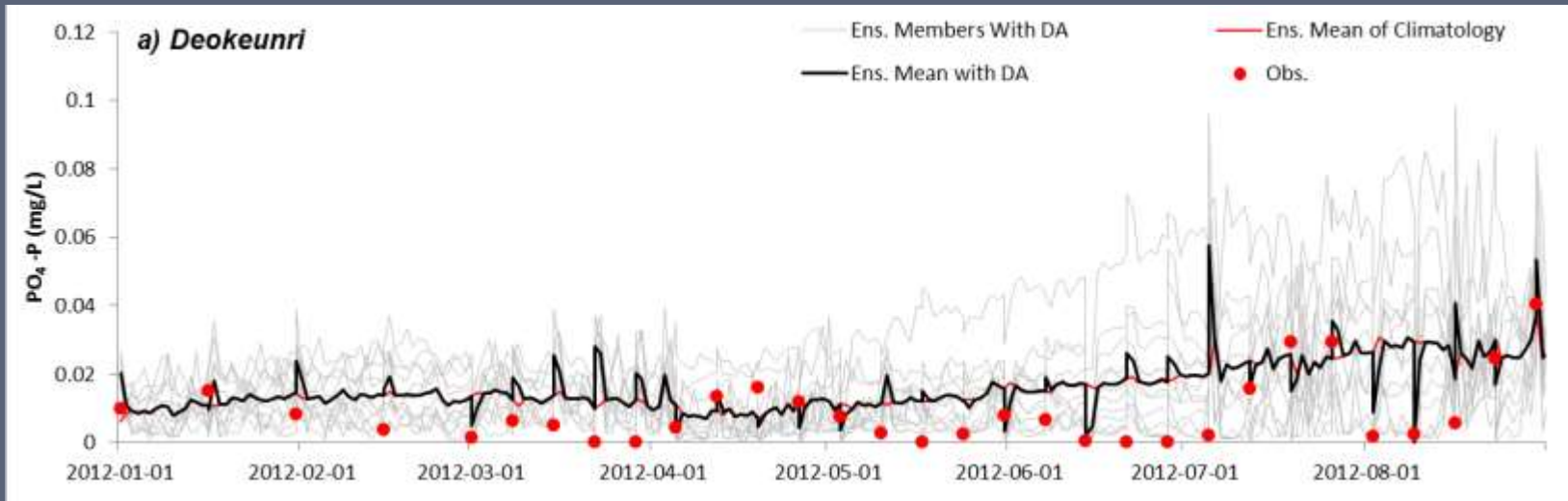
Correlation among WQ variables

Model equations

Chl-a

$$\frac{\partial B_x}{\partial t} = (P_x - BM_x - PR_x)B_x + \frac{\partial}{\partial z}(WS_x \cdot B_x) + \frac{WB_x}{V}$$
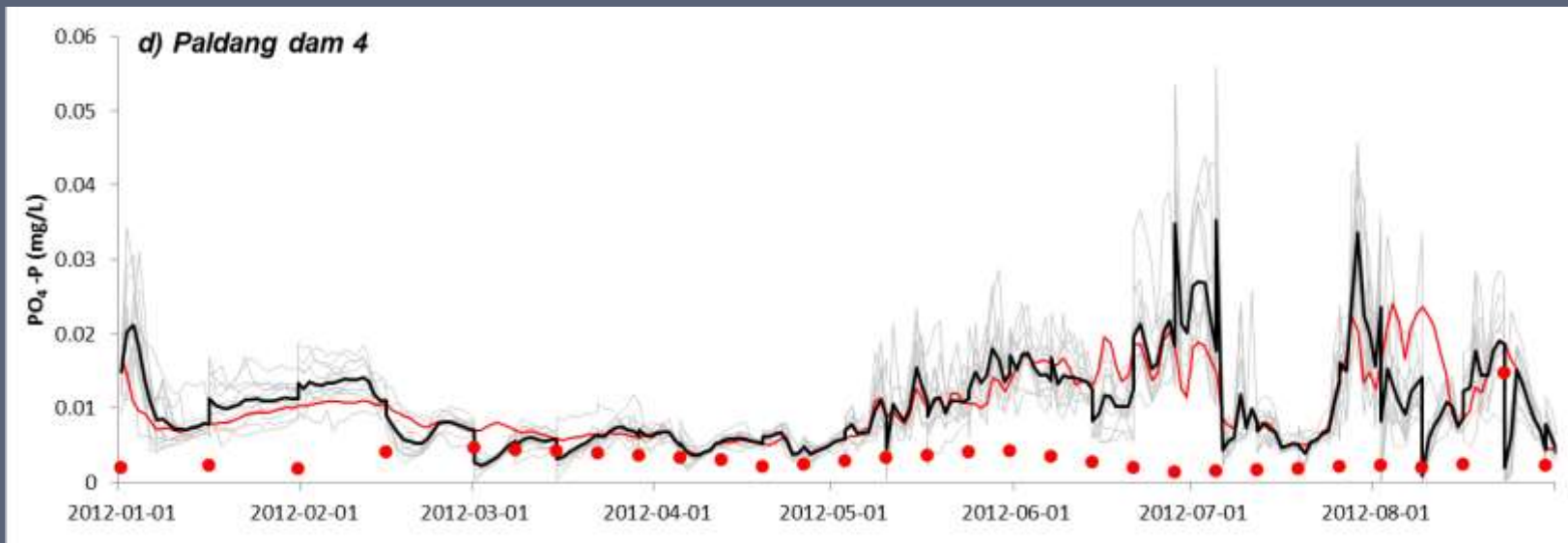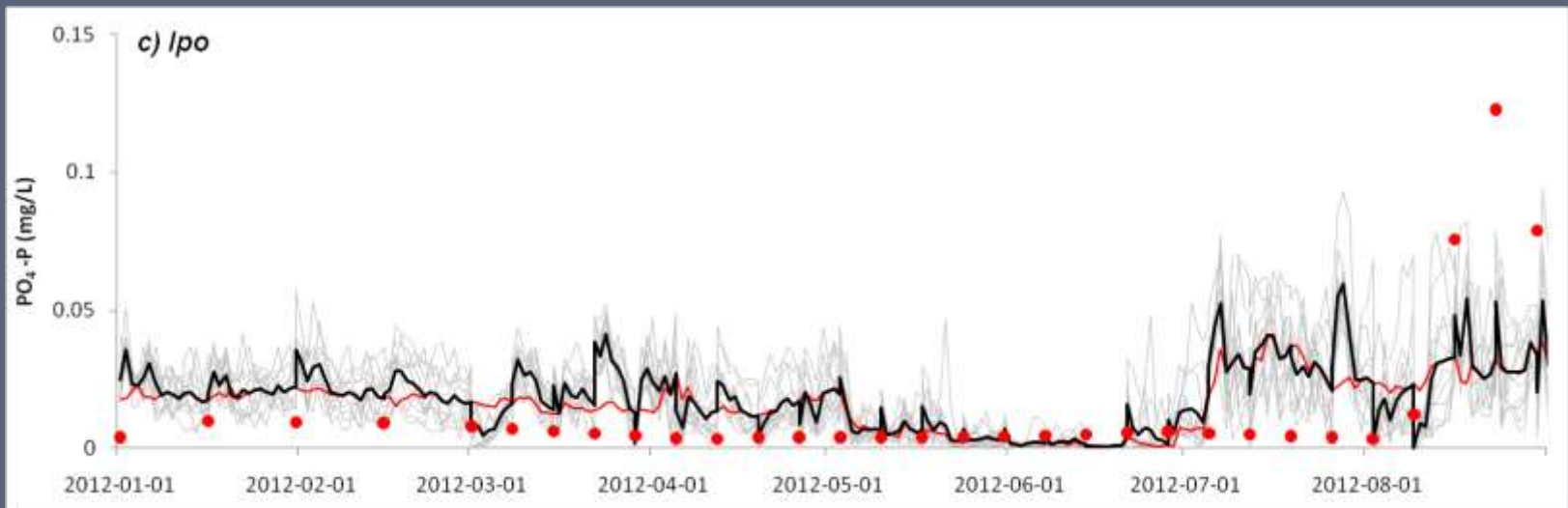
PO4

$$\frac{\partial PO4t}{\partial t} = \sum_{x=c,d,g,m}(FPI_x \cdot BM_x + FPIP \cdot PR_x - P_x)APC \cdot B_x + K_{DOP} \cdot DOP$$

$$+ \frac{\partial}{\partial z}(WS_{TSS} \cdot PO4p) + \frac{BFPO4d}{\Delta z} + \frac{WPO4t}{V}$$

Results of phosphate ensemble simulation with DA

Results of Chl-a ensemble simulation with DA

Synthetic experiment

- ❖ 'Ill-posed ensemble' in terms of correlation among WQ variables due to ignorance of spatial correlation of the boundary forcing to EFDC (perturbed HSPF outputs) and lack of consideration on correlation between observed WQ variables
- ❖ Synthetic experiment for 'well-posed ensemble'
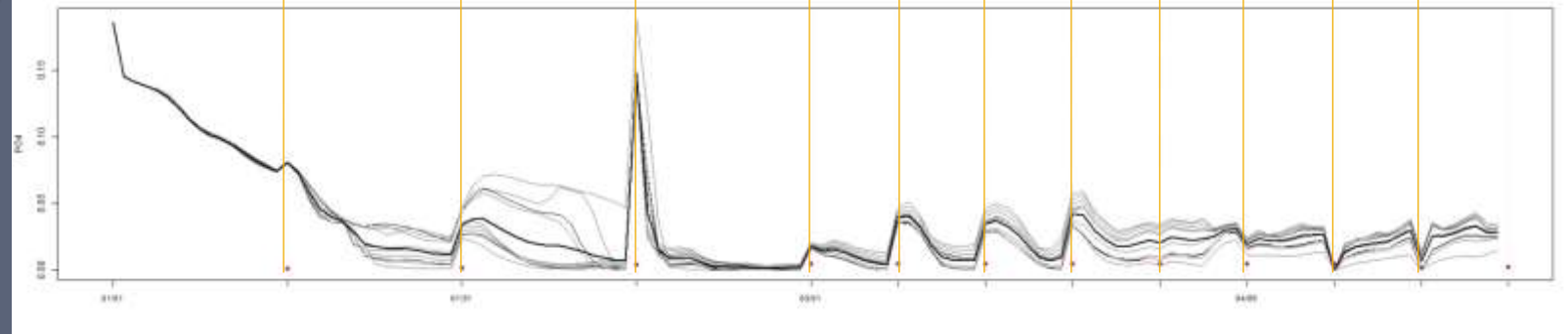 - – Perturbed water temperature only and left other WQ variables as single time series in the boundary forcing
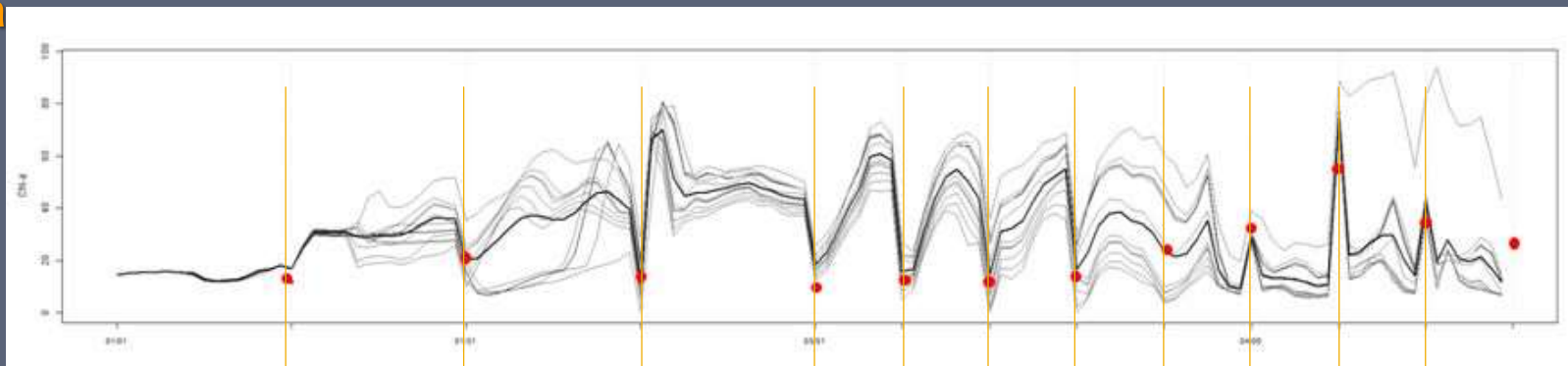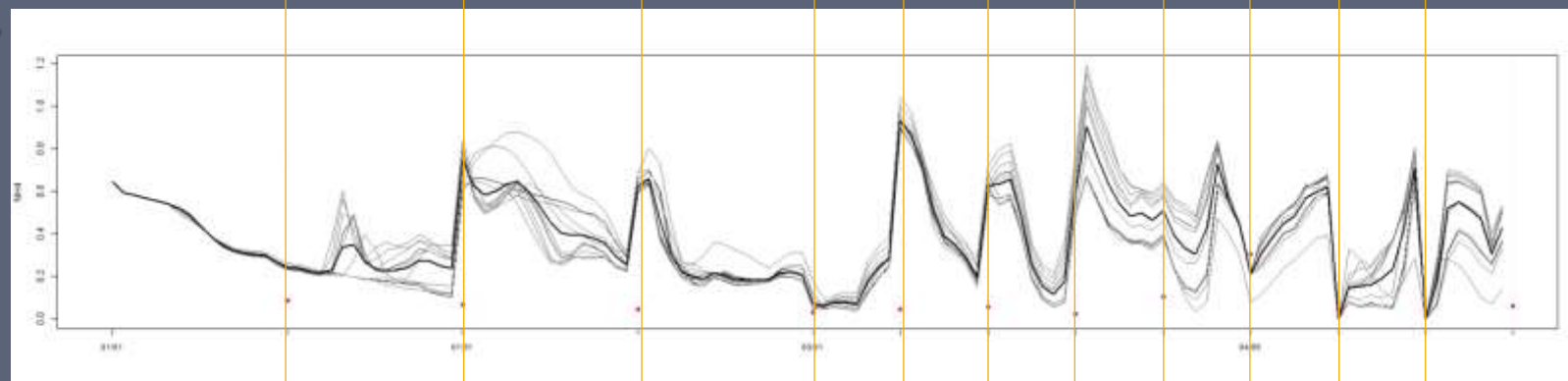
Synthetic experiment

Chl-a

PO4
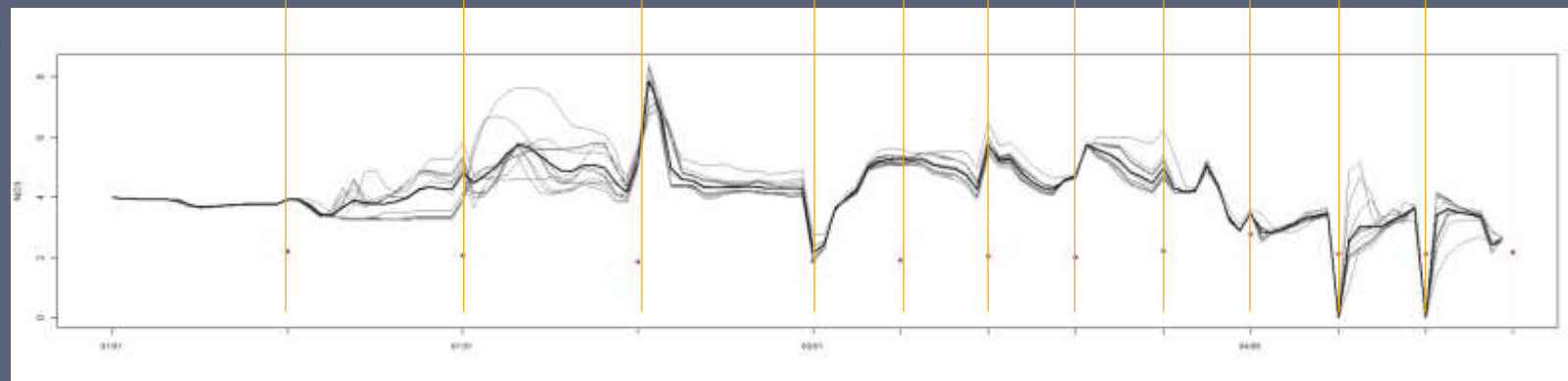
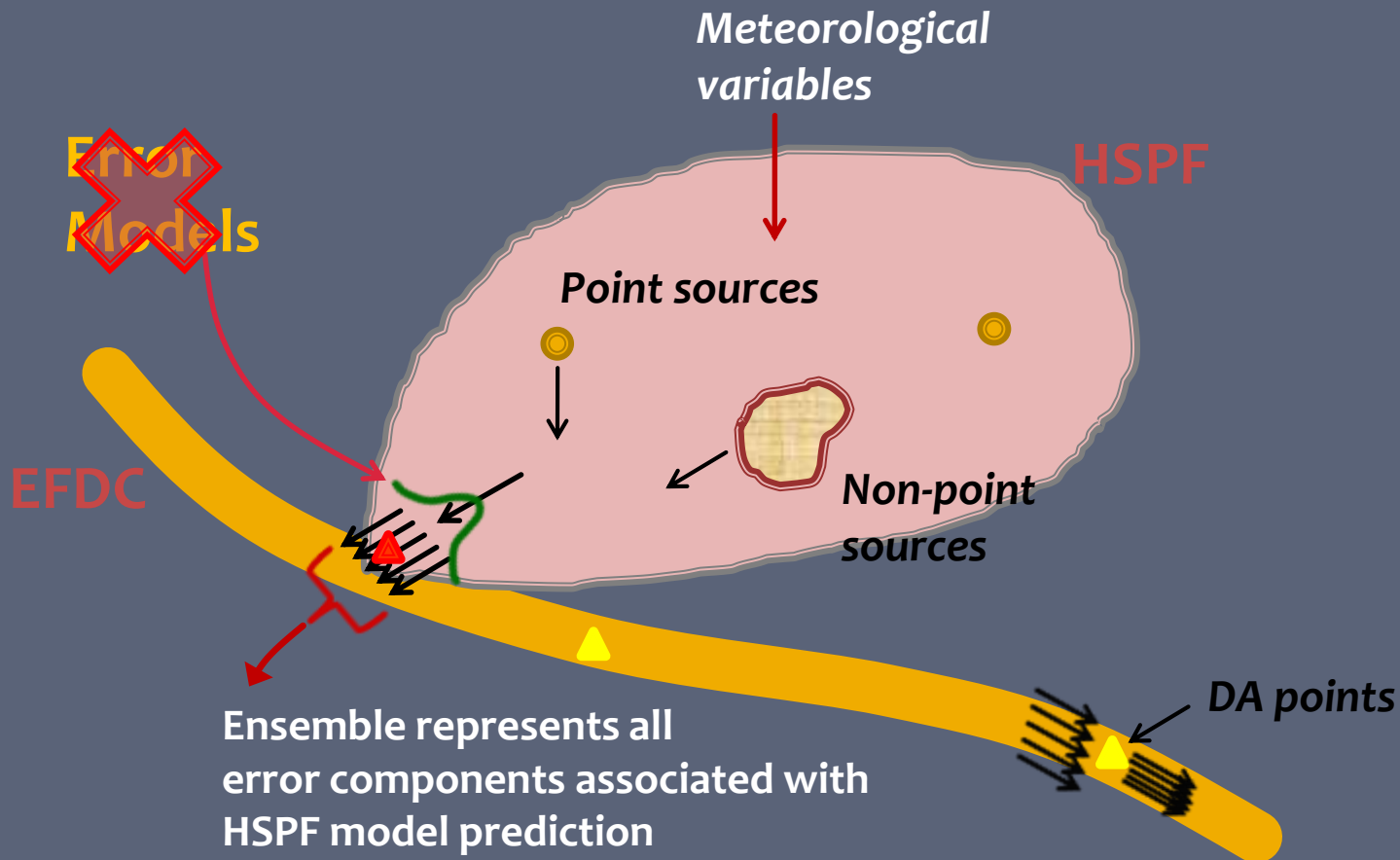# Synthetic experiment
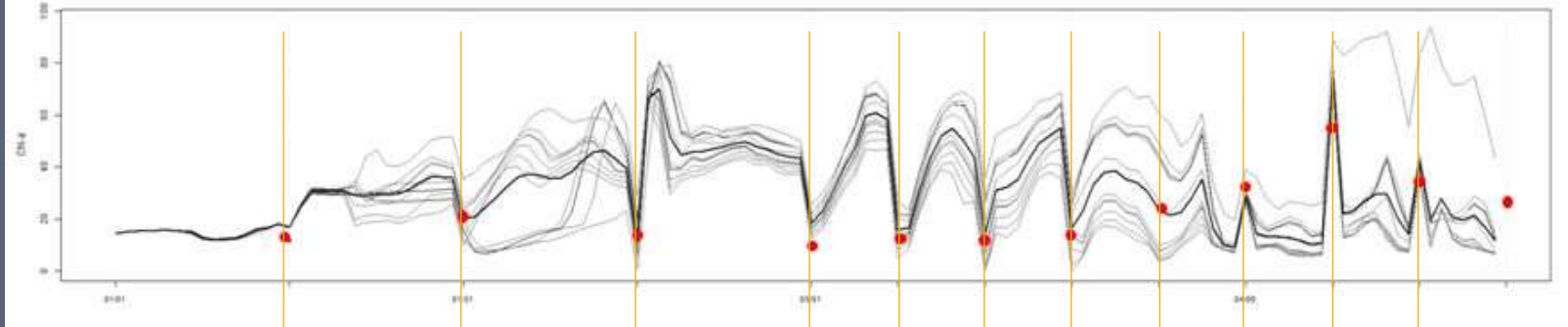
Chl-a
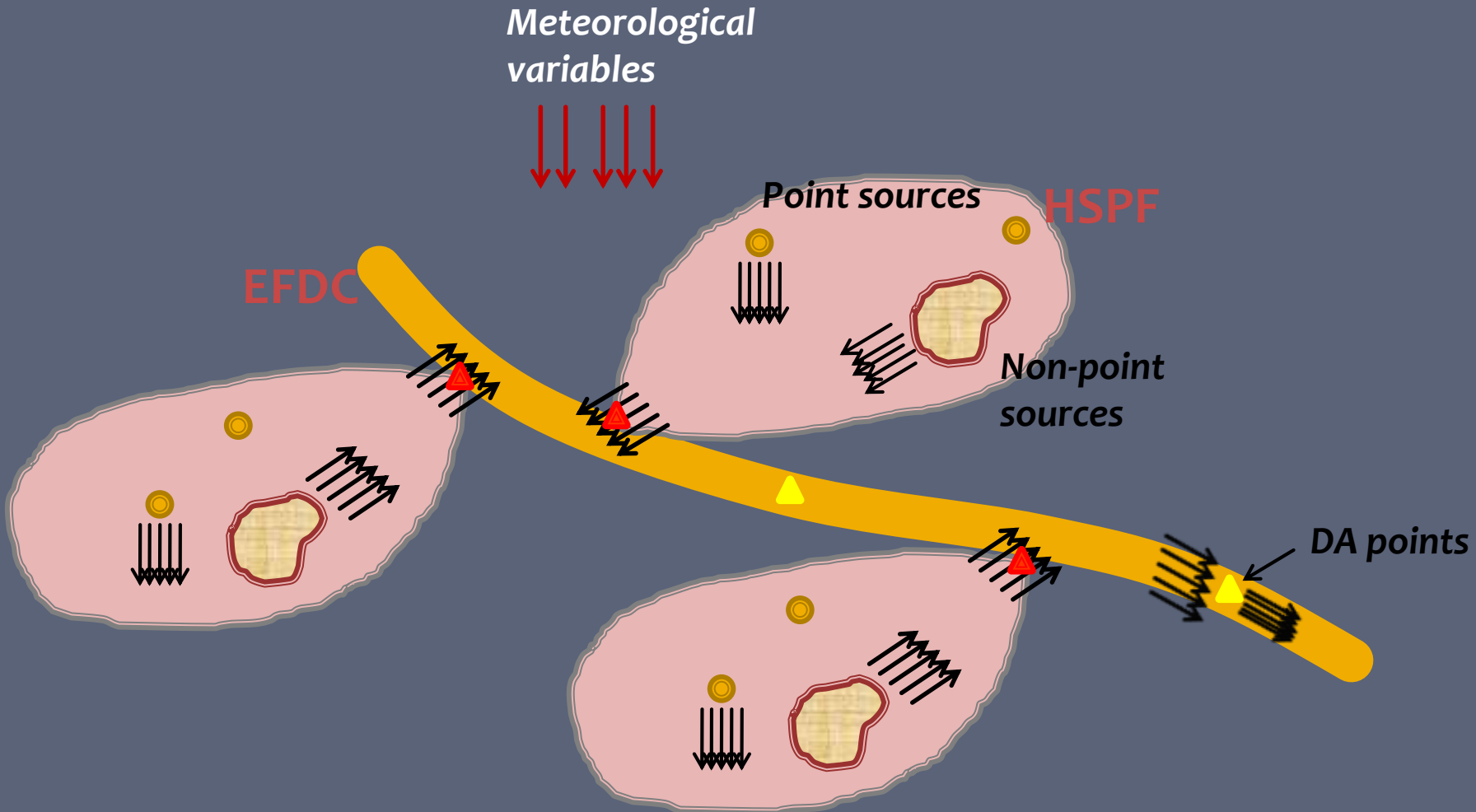

PO4

Chl-a

NH4

NO3

So what is a proper approach?

❖ **Our approach using error models is wrong. It is very difficult to consider spatial and inter variable correlations in this framework**

Meteorological variables

HSPF

Error Models

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Non-point sources

EFDC

DA points

Ensemble represents all error components associated with HSPF model prediction

So what is a proper approach?

❖ **In stead, ensemble simulation of the entire watershed is necessary**

Thank you

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