Seasonal Streamflow Forecasts Based On Physical-Based Model for Chao Phraya River Basin in Thailand

東京工業大学
Tokyo Institute of Technology

Wongnarin Kompor*
kompor.w.aa@m.titech.ac.jp
Natsuki Yoshida
yoshida.n.al@m.titech.ac.jp
Sayaka Yoshikawa
yoshikawa.s.ad@m.titech.ac.jp
Shinjiro Kanae
kanae@cv.titech.ac.jp

Department of civil engineering
Tokyo Institute of Technology
Tokyo, Japan

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Outline

- Introduction
  - Problem
  - Previous studies
  - Objective
- Data and Methodology
  - Study area
  - Data
  - Methodology
- Results and discussion
- Conclusion

Bhumibol Dam

Sirikit Dam

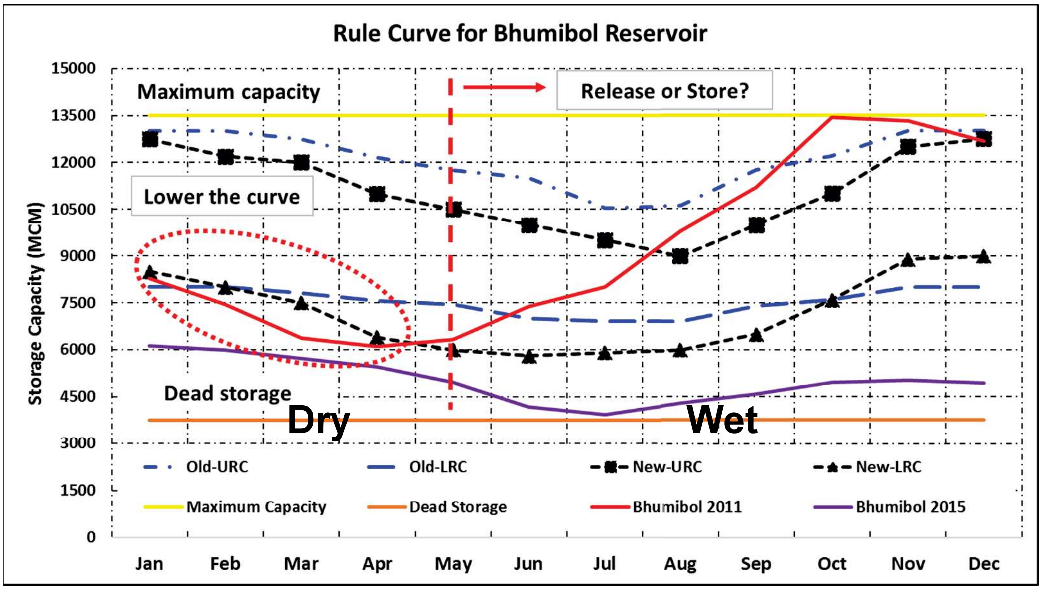
Introduction

➢**Problem**

- **Thailand's water management**
- **Rule curve**

- **Difficulty in water management**
- **Seasonal forecast**
- **Transition season**

Thailand Water Management



Old Rule Curve	New Rule Curve
2011	2015

Source: EGAT

3

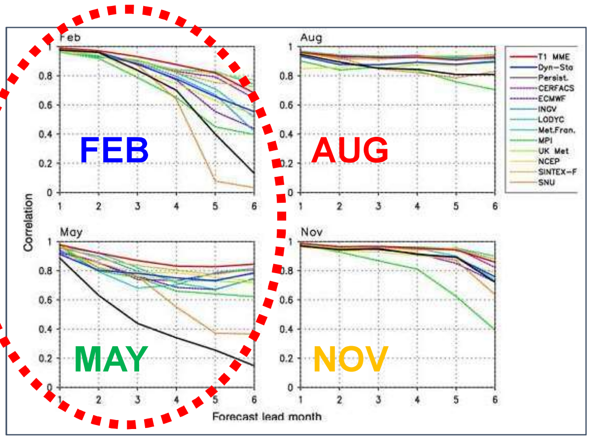
Introduction

➢**Previous studies**

- **A hydrological model is forcing with a range of probability in seasonal climate forecast (ensemble streamflow prediction; ESP)**
- **Wood et al. 2016 indicated the predictability of streamflow prediction.**
- **The most predictability at seasonal scales are during winter**
- **The smallest predictability found at the end of a climatologically (dry → wet)**

Prediction skill is lower

Spring Predictability Barrier (SPB)



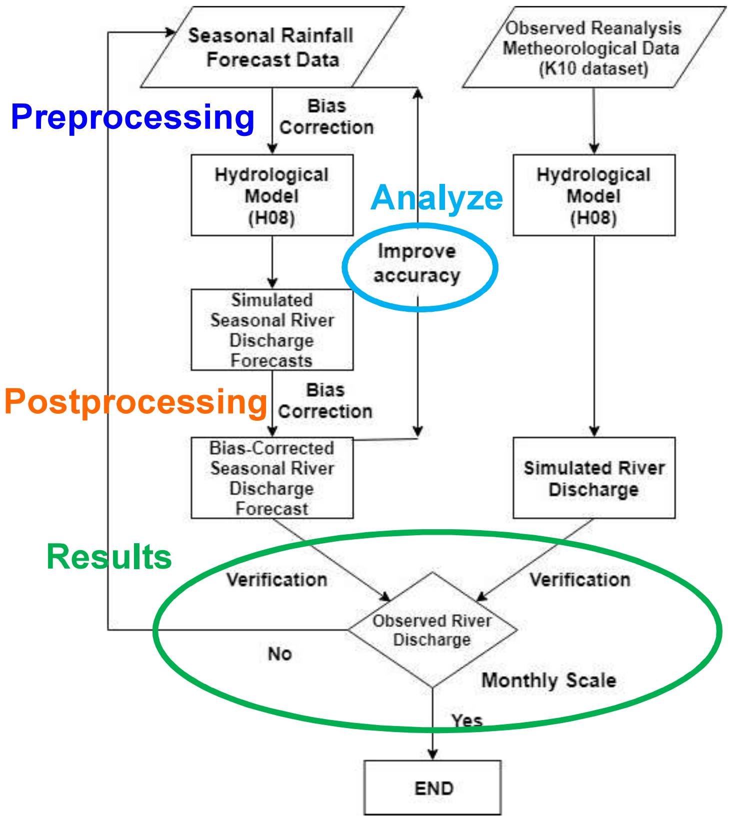
Jin et al. 2008

4

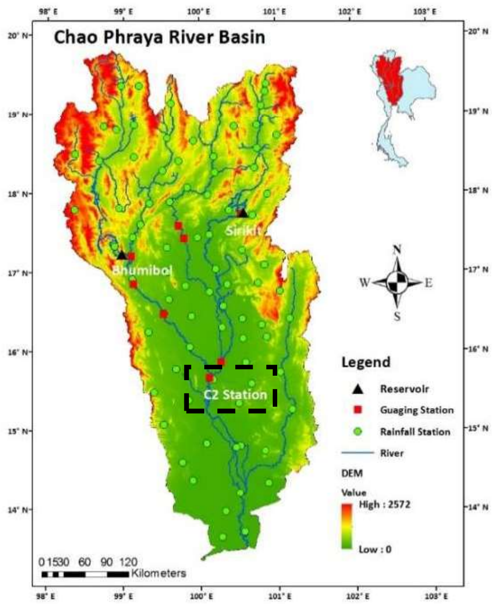
Objective

- Clarify the effect of SPB, which have the evidence in a global scale, to the predictability of river discharge in Chao Phraya River Basin (CPRB)
- Evaluate the accuracy of seasonal streamflow forecasts on each initial prediction day

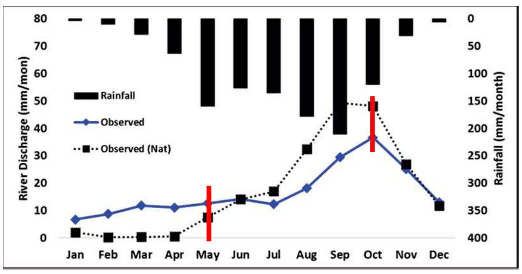
Data and Methodology



Experiment Setting



Dry and Wet Season

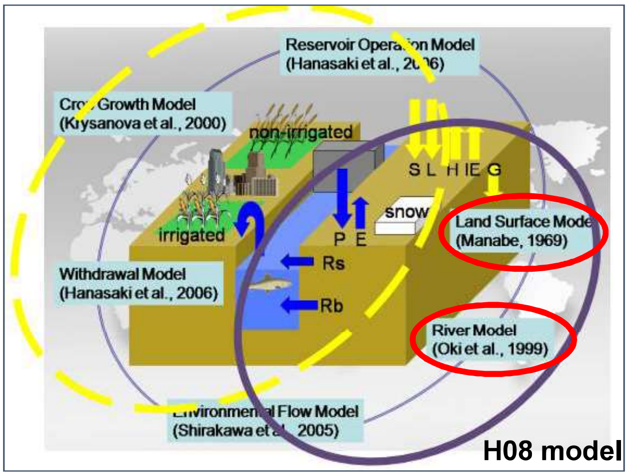


Study area

Data and Methodology

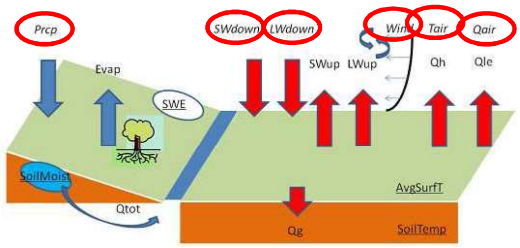
➢ **Hydrological model**

Model was developed by Hanasaki et al. 2008a



H08 model

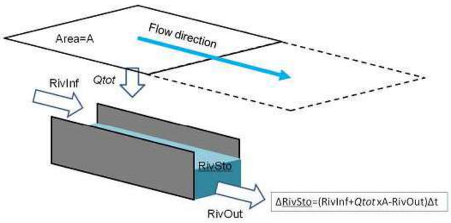
Land surface model



Soil water balance **Energy balance**

Soil water balance $$\frac{dW}{dt} = Rainf + Q_{sm} - E - Q_s - Q_{sb}$$

Energy balance $$(1-\alpha)SW^{\downarrow} + LW^{\downarrow} = \sigma T_S^4 + \iota E + H + G$$



River model

$$\Delta RivSto = (RivInf + Q_{tot}A - RivOut)\Delta t$$

Data and Methodology

➢ **Data**

- <u>**Observed data**</u>

- Rainfall data (1981-2004)

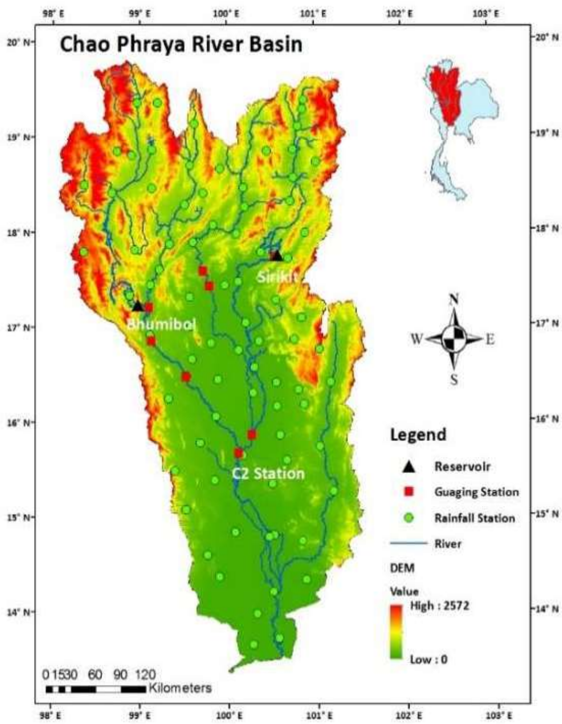
Thai Meteorological Department (TMD)

Royal Irrigation Department (RID)

- River discharge data at C2 station

Royal Irrigation Department (RID)

● **Rainfall Station**
■ **Gauging Station**
▲ **Gauging Station**

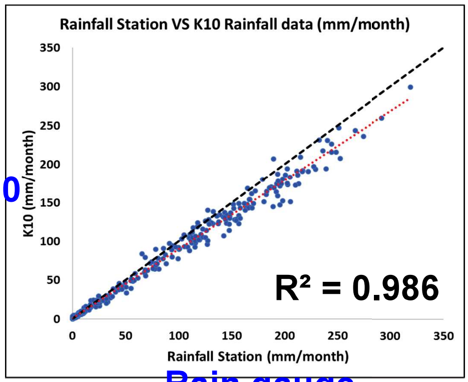


Data and Methodology

- <u>Meteorological forcing data</u>
  - Kotsuki et al. 2010 provide a set of meteorological data (K10)
  - Developed from rain gauge station in CPRB
  - Several study used K10 as input data

Data period: 1981-2004
- ✓ Surface air temperature (3-hourly)
- ✓ Specific humidity (daily)
- ✓ Surface air pressure (1-hourly)
- ✓ Wind speed (1-hourly)
- ✓ Shortwave radiation (3-hourly)
- ✓ Longwave radiation (3-hourly)
- ✓ Precipitation (daily)
- ✓ Data resolution : 5 min. grid resolution

K10



Rain gauge

Comparison between observed rainfall and K10 rainfall data in CPRB

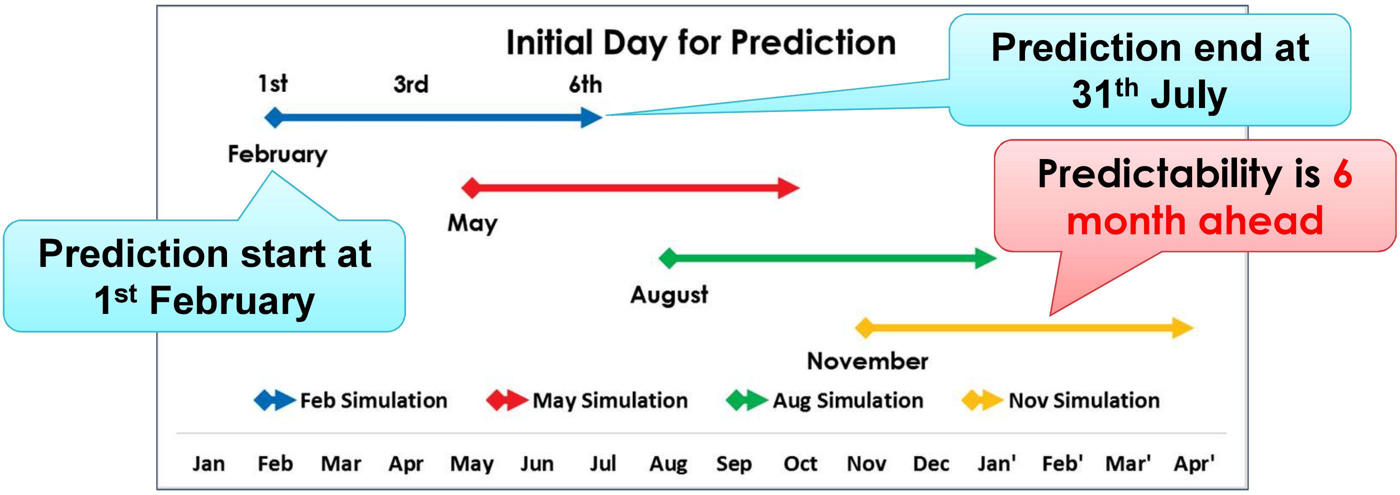
Data and Methodology

- Seasonal Rainfall Prediction (Imada et al. 2015)
  - Easy to access for utilizing
  - Focused in Thailand's meteorological

Rainfall = APHRODITE* + Anomaly

Data period: 1979-2011
- Anomaly Precipitation (Ref.year 1961-2000; monthly time scale)
- 8 Ensembles

Downscaling 1.4 degree to 5 min resolution



Month

*Yatagai et al., 2009

Data and Methodology

➢ **Methodology**

- **Preprocessing and postprocessing**

Taking bias correction techniques to remove the systematic bias of both hydrological model and climate variables

<u>Linear scaling (LS)</u>

- **Grid-to-grid monthly correction**
- **Corrected mean value between model and observed**

$$P_{cor,d,i,j} = P_{sim,d,i,j} \times \frac{\sum_{j=1981}^{2004} P_{obs,d,i,j}}{\sum_{j=1981}^{2004} P_{sim,d,i,j}}$$

cor = bias-corrected data

obs = observed data

sim = simulated data

i = month (Jan, Feb,…, Dec)

j = year (1981, 1983,…, 2004)

d = day (1,2,3,4,5…31 or 30 or 28 or 29)

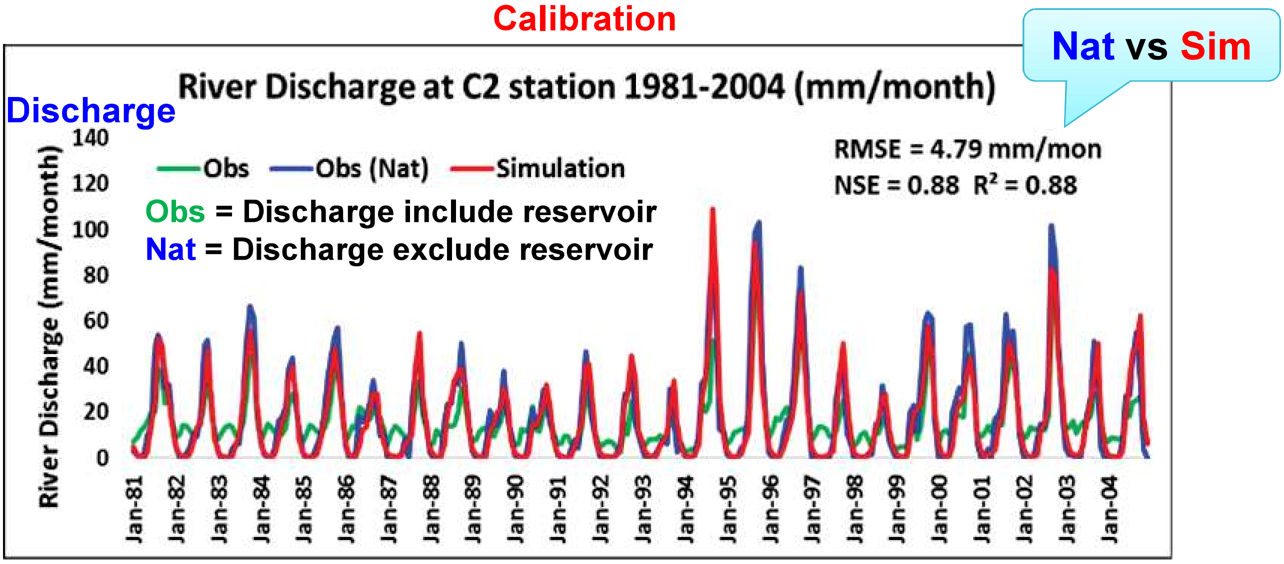
11

Results and discussion

- **Model Calibration**

- H08 was driven by <u>K10 data to simulated</u> river discharge from 1981 to 2004

Calibration



Month

Overall, The river discharge simulation by K10 data shows a good results

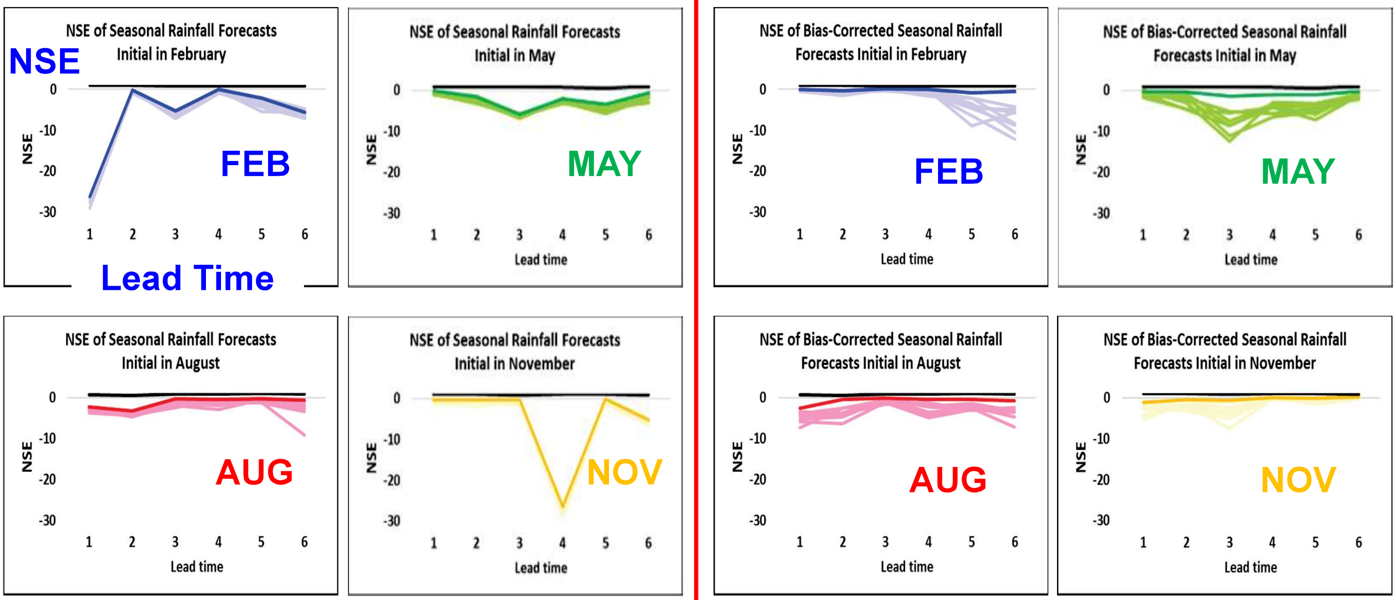
12

Results and discussion

- **Preprocessing (Bias correction of rainfall prediction)**

  - Remove bias from seasonal rainfall prediction (Linear Scaling)

RAW → Bias Correction → Preprocessing



NSE, range from -∞ to 1

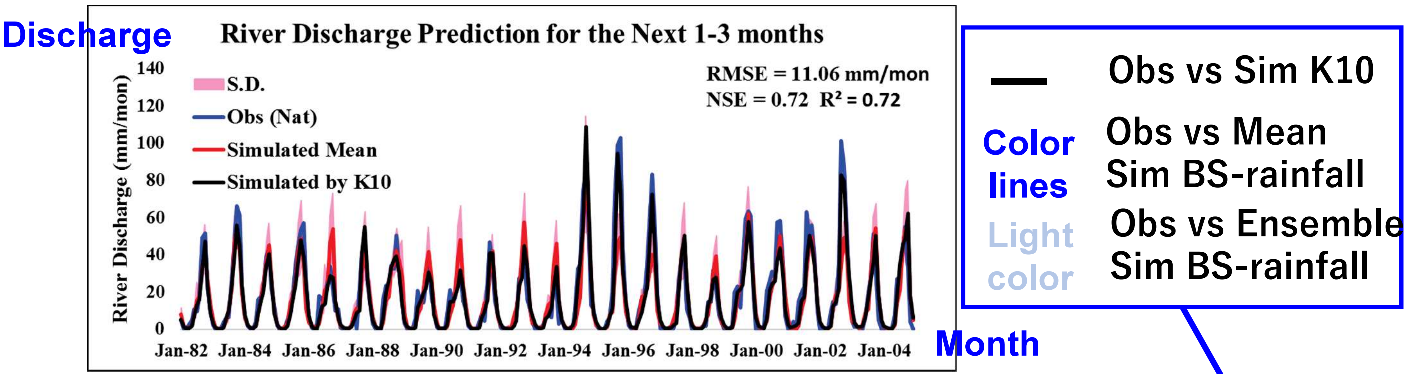
13

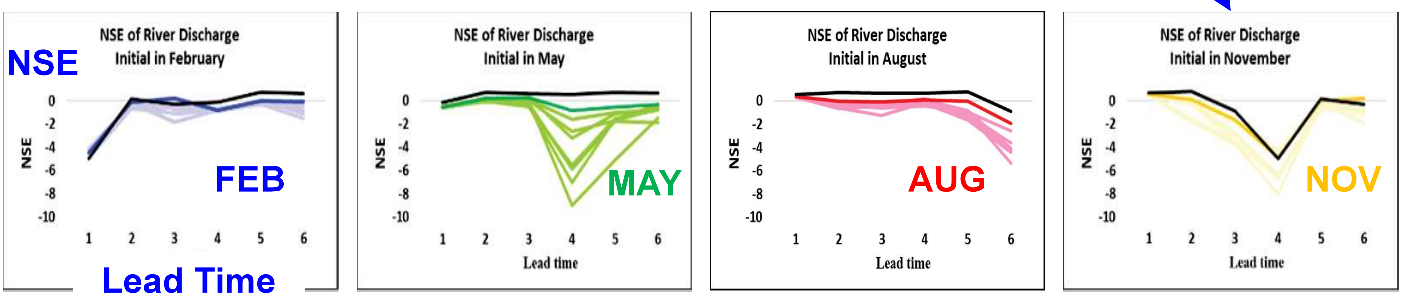
Results and discussion

- **River discharge simulation**

  - H08 model was simulated by bias-corrected rainfall prediction

Prediction - Preprocessing





NSE, K10 Sim

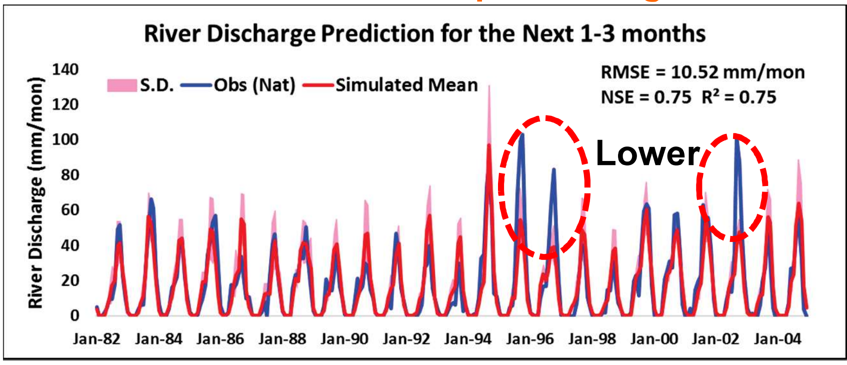
14

Results and discussion

- **Postprocessing**

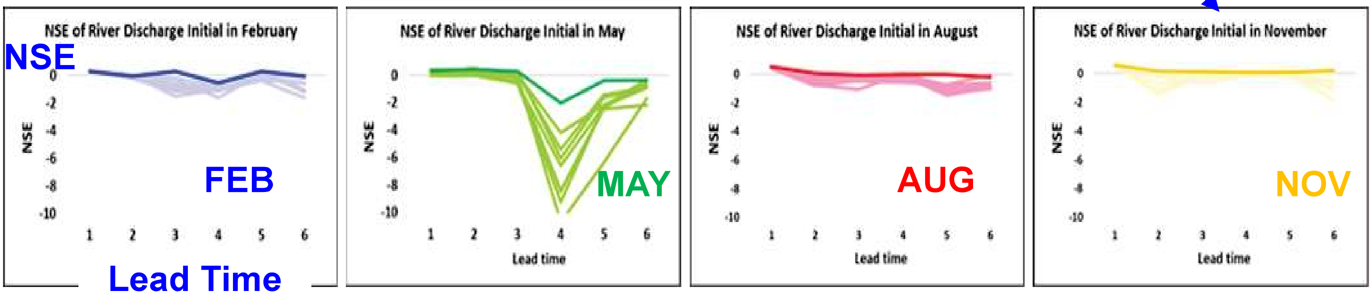
  - Bias-corrected river discharge simulation from last slide

Prediction - Postprocessing



BS Discharge with Obs

Color lines	Obs vs Mean Sim BS-rainfall
Light color	Obs vs Ensemble Sim BS-rainfall

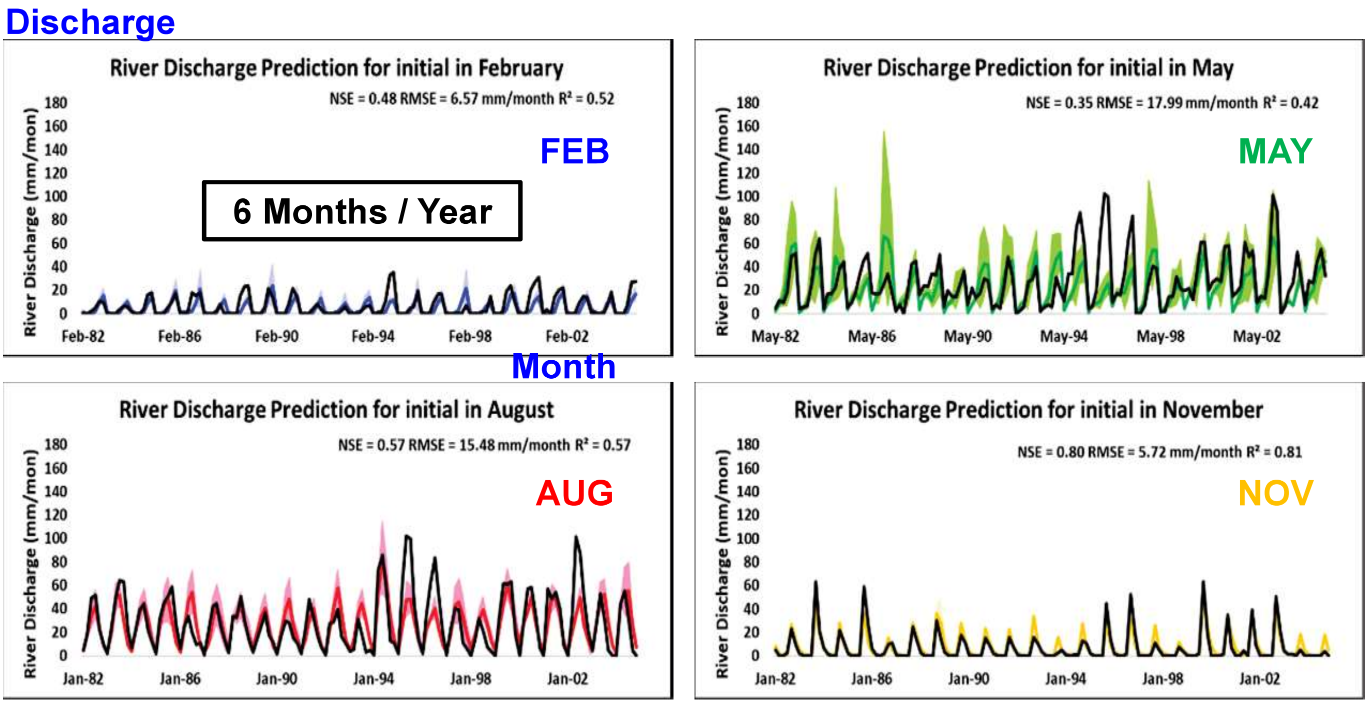


NSE, range from -∞ to 1 Bias correction fix mean of data but not peak

Results and discussion

- **Postprocessing**

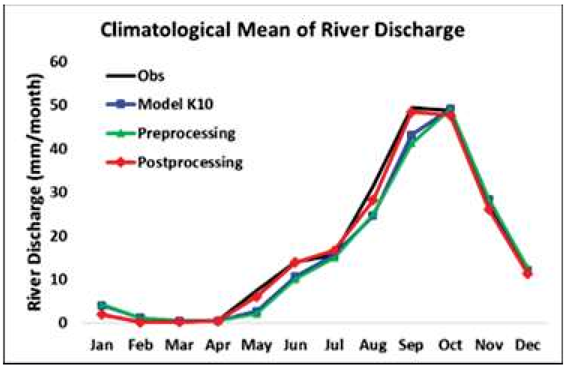
  - River discharge simulation for each initial month



Conclusion

- The results of the accuracy of the next 1 to 3 months in river discharge prediction were better in accuracy than river discharge prediction for the next 4 to 6 months
- We found that the effect of SPB on rainfall prediction shows less predictability on May that effected on lower river discharge prediction skills during spring, which initial day for prediction is the first day of February and May

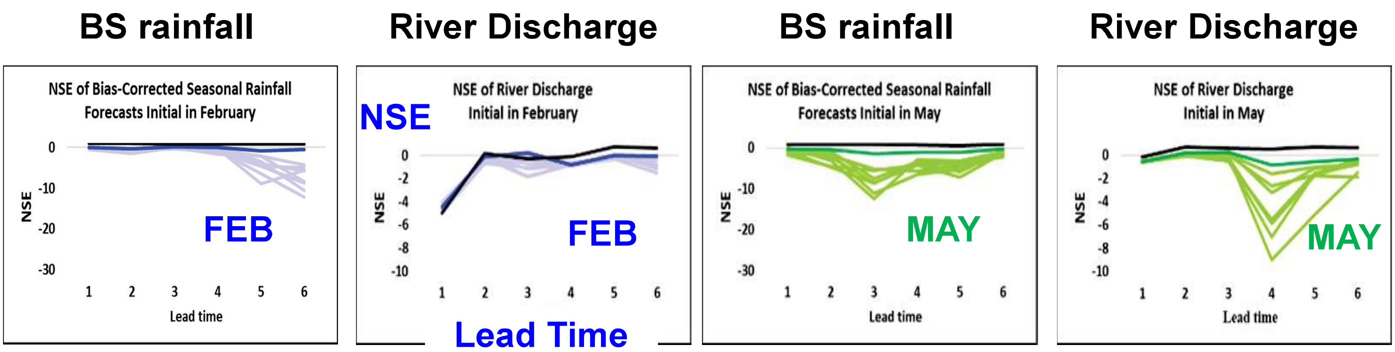
- Bias Correction fix mean of data



17

Conclusion

- Bias between observed river discharge and simulated river discharge arise from the H08 model and rainfall prediction. Therefore, a study of prediction rainfall and SPB is important for river discharge prediction especially during the transitional time (end of dry season to wet season)



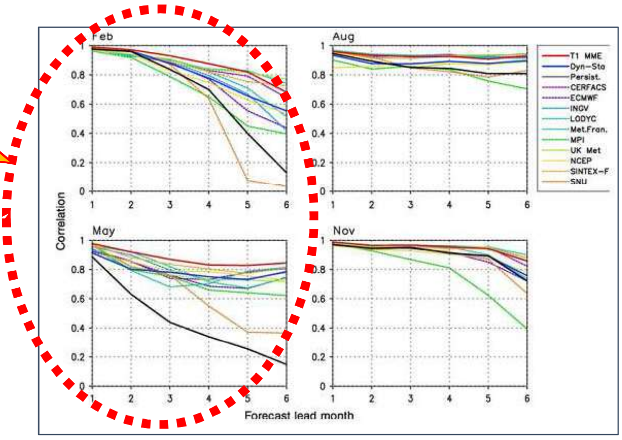
18

THANK YOU FOR YOUR ATTENTION

Introduction

However, there was an issue on the low accuracy of seasonal prediction for climate variables on spring, which is so-called "spring predictability barrier (SPB)", is identified critical issue for seasonal prediction in global scale

Prediction skill is lower

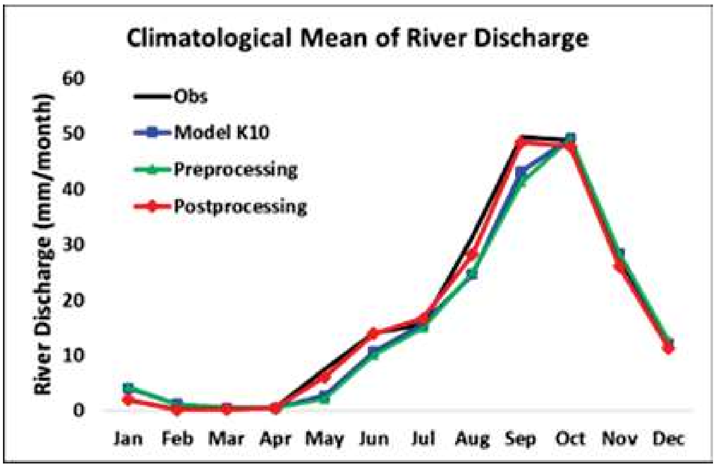


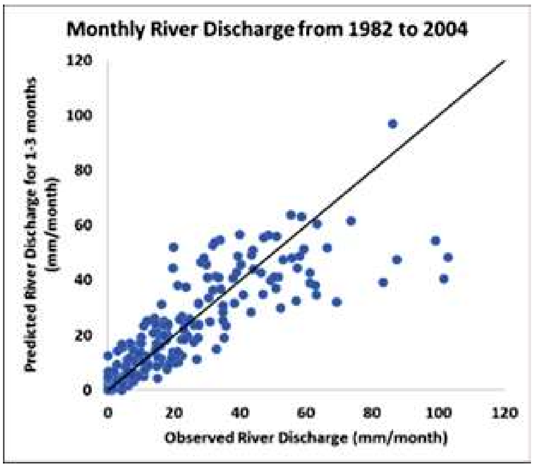
Jin et al. 2008

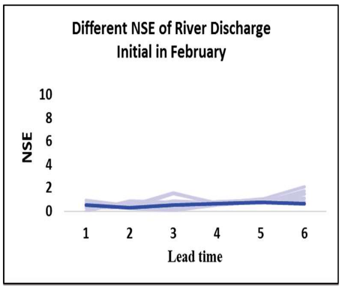
➢Objective

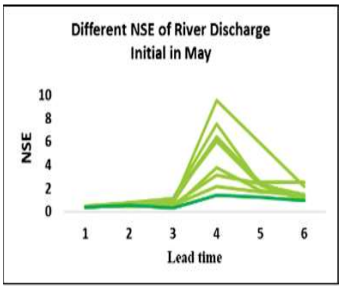
- **Clarify the effect of SPB, which have the evidence in a global scale, to the predictability of river discharge in CPRB**
- **Evaluate the accuracy of seasonal streamflow forecasts on each initial prediction day**

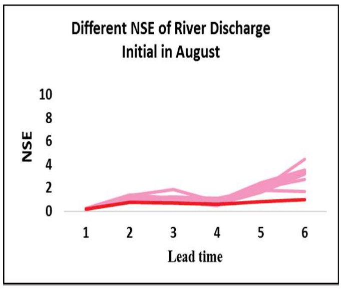
Results and discussion

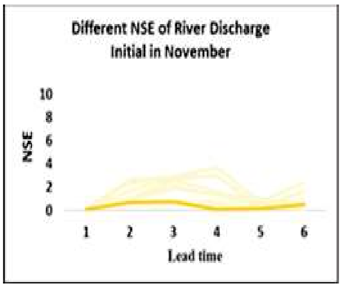








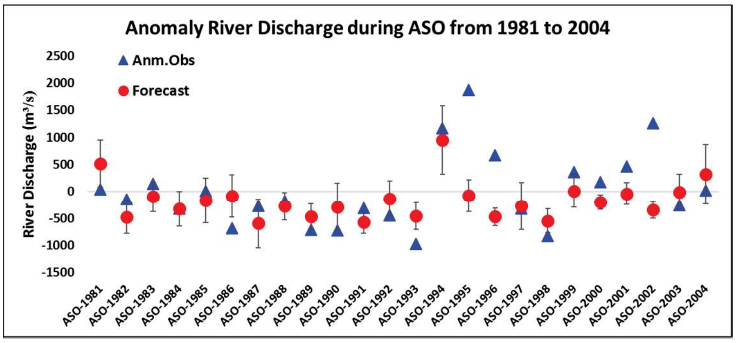


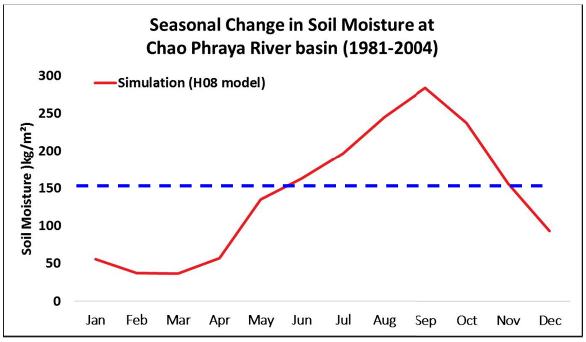


Results and discussion

Average during August, September and October

Average soil moisture





Index

➢ **Nash-Sutcliffe model efficiency coefficient (NSE)**

Nash-Sutcliffe model efficiency coefficient (NSE) used to indicate the accuracy (predictive power) between observed data and simulated data of the hydrological model. NSE can range from -∞ to 1 which an efficiency of 1 means a perfect match between simulated discharge and observed data. NSE equals to 0 indicates that the model predictions are accurate as the mean of observed data where below 0 means the observed mean is a better predictor than the model.

$$\text{NSE} = 1 - \frac{\sum_{t=1}^{T}\left(Q_m^t - Q_o^t\right)^2}{\sum_{t=1}^{T}\left(Q_o^t - \overline{Q_o}\right)^2}$$

where Q_m^t is model data, Q_o^t is observed data and $\overline{Q_o}$ is average value of observed data.