Assessment of Climate Change Impacts on Environmental Flow Release from a Multi-purpose Dam of South Korea Using SWAT Model

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SWAT Soil & Water Assessment Tool

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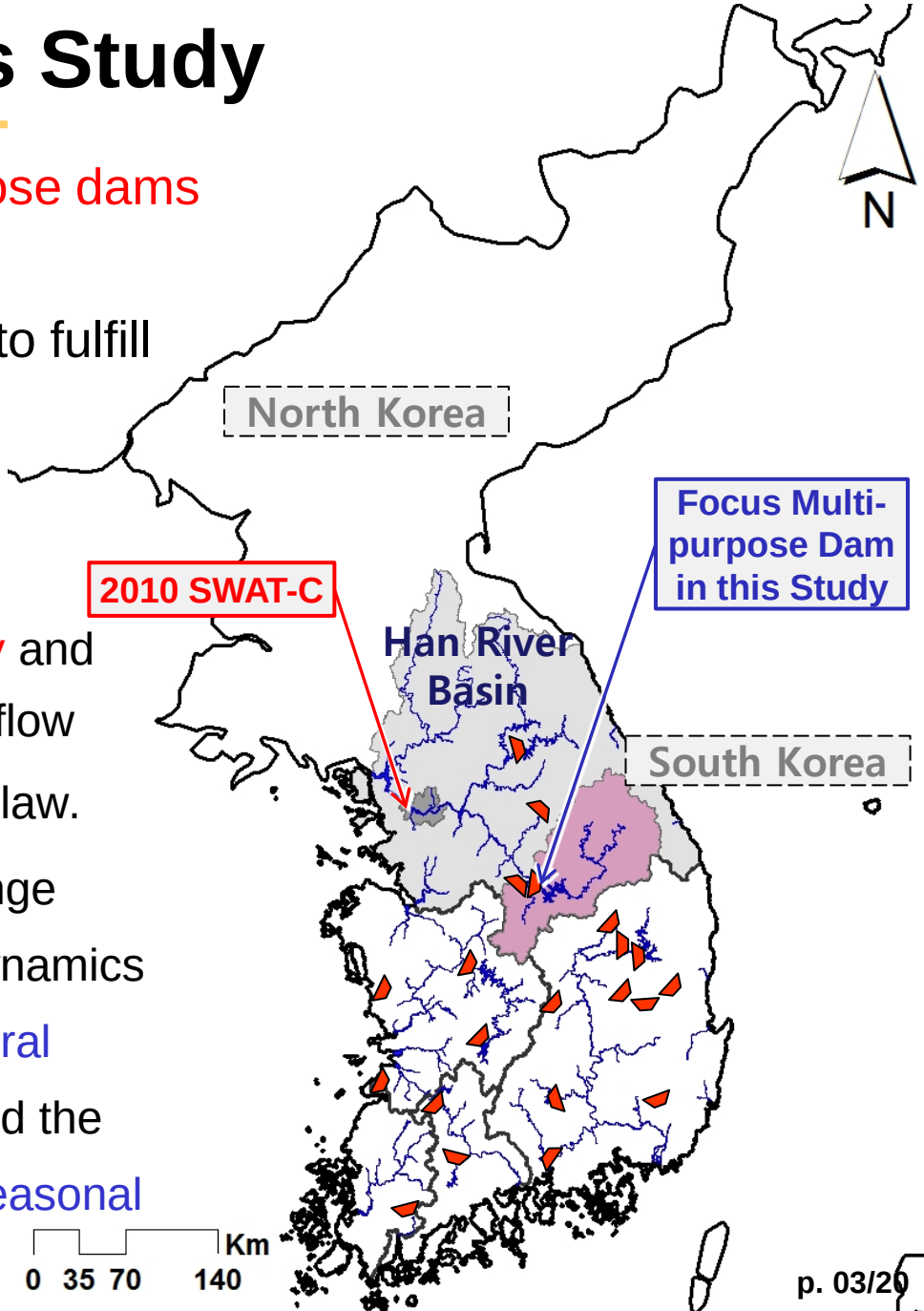
Contents

1. Background of This Study

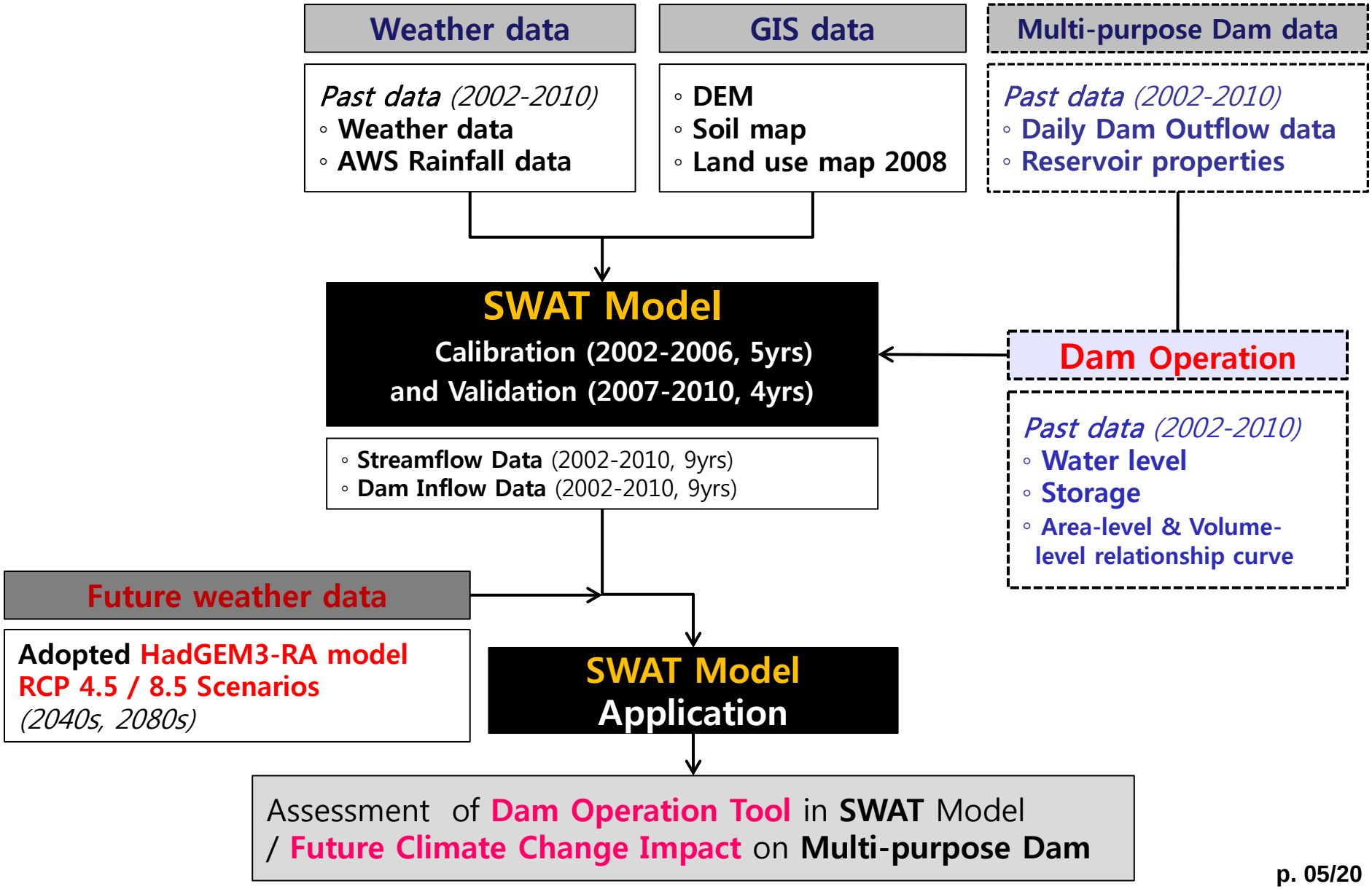
- At present, we have 20 multipurpose dams in South Korea. They have been successfully managed by K-water to fulfill water demands, flood control and hydropower generation.
  - Recently, our people require river maintenance flow for water quality and healthy eco-environment and the flow has been secured by government law.
  - We can infer that the climate change certainly affects the dam inflow dynamics from the watershed. By the temporal variations of dam storage, we need the adjustment of operation rule for seasonal target release in a monthly base.



1. Background of This Study

- Using SWAT dam operation, we try to evaluate the availability of maintenance flow under the future climate change scenarios.
  - Assuming the future water demands of living, industry, and agriculture are not changed and applying the present monthly target release, we will discuss the future maintenance flow to the downstream by looking at the future temporal variations of dam storage.
  - For a 8,245.6 km^2 watershed including two dams (one is main dam and the other is regulation dam at the downstream), the SWAT was setup using 9 years (2002-2010) dam inflow and storage data, and assessed the storage and flow by applying RCP 4.5 and 8.5 scenarios (2040s, 2080s) of HadGEM3-RA model.

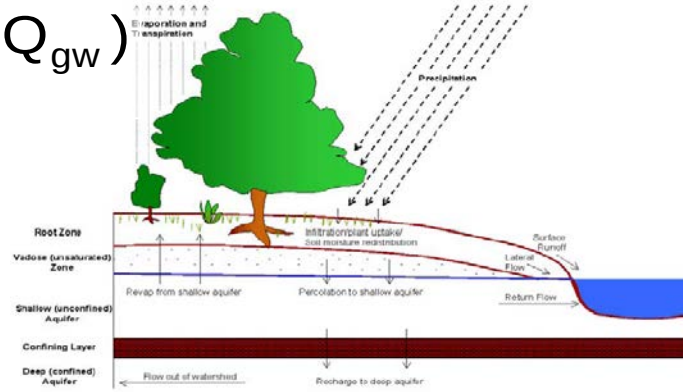
2. Flowchart of Study



3. Focus of SWAT Run in this study

❑ Water balance equation

$$SW_t = SW_0 + \sum_{i=1}^{t} (R_{day} - Q_{surf} - E_a - W_{seep} - Q_{gw})$$

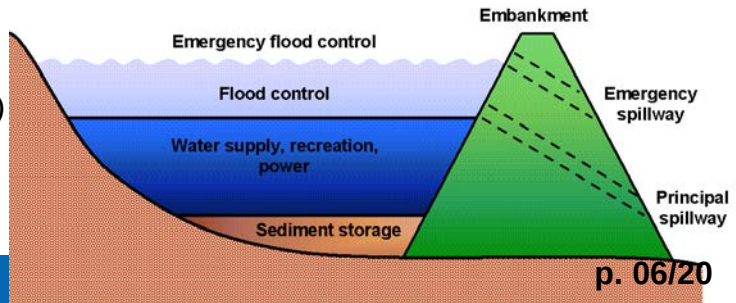


- SW_t = *Final soil water content (mm)*
- SW_0 = *Initial soil water content on day i (mm)*
- R_{day} = *Amount of precipitation on day i (mm)*
- Q_{surf} = *Amount of surface runoff on day i (mm)*
- E_a = *Amount of evapotranspiration on day i (mm)*
- W_{seep} = *Amount of water entering the vadose zone from the soil profile on day i (mm)*
- Q_{gw} = *Amount of return flow on day i (mm)*

❑ The water balance for a reservoir

$$V = V_{stored} + V_{flowin} - V_{flowout} - V_{pcp} - V_{evap} - V_{seep}$$

- $V_{pcp} = 10 \cdot R_{day}$ *(precipitation)* $\cdot$ *SA (surface area)* (m^3H_2O)
- $V_{evap} = 10 \cdot \eta$ *(evaporation coefficient: 0.6)* $\cdot$ E_0 *(potential ET)* $\cdot$ *SA* (m^3H_2O)
- $V_{seep} = 240 \cdot K_{sat}$ *(effective saturated hydraulic conductivity)* $\cdot$ *SA* (m^3H_2O)



3. Focus of SWAT Run in this study

$V_{flowout}$

Measured Daily, Monthly (IRESCO = 3,1)

$$V_{flowout} = 86400 \cdot q_{out} \text{ [outflow rate, } m^3/s \text{]} \ (m^3 H_2O)$$

Target Release For Controlled Reservoir (IRESCO = 0)

$$V_{flowout} = \frac{V - V_{targ}}{ND_{targ}}$$

$$V_{targ} = V_{pr} + \frac{(1 - \min[\frac{SW}{FC}, 1])}{2} \bullet (V_{em} - V_{pr})$$

if $mon \le mon_{fld,beg}$ (beginning month of the flood season)

or $mon \ge mon_{fld,end}$ (ending month of the flood season)

V_{targ}: target reservoir volume (m^3 H_2O)

ND_{targ}: number of days required for the reservoir to reach target storage

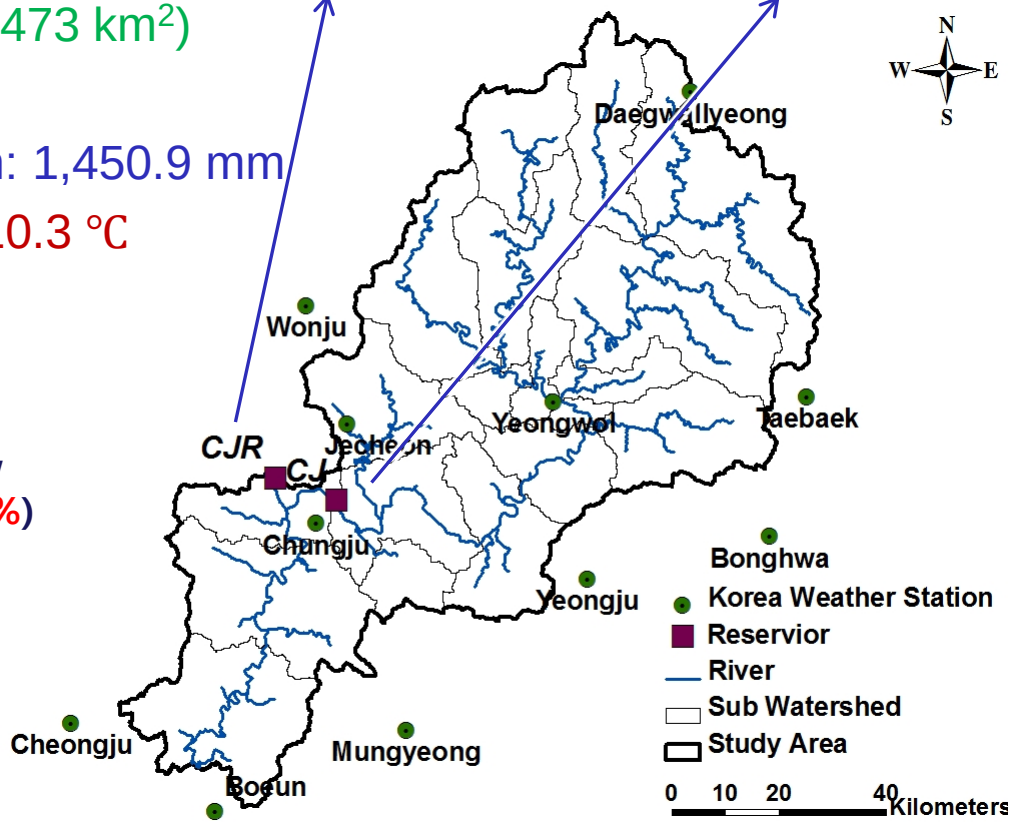
V_{em}: volume of water held in the reservoir when filled to the emergency spillway (m^3 H_2O)

V_{pr}: volume of water held in the reservoir when filled to the principal spillway (m^3 H_2O)

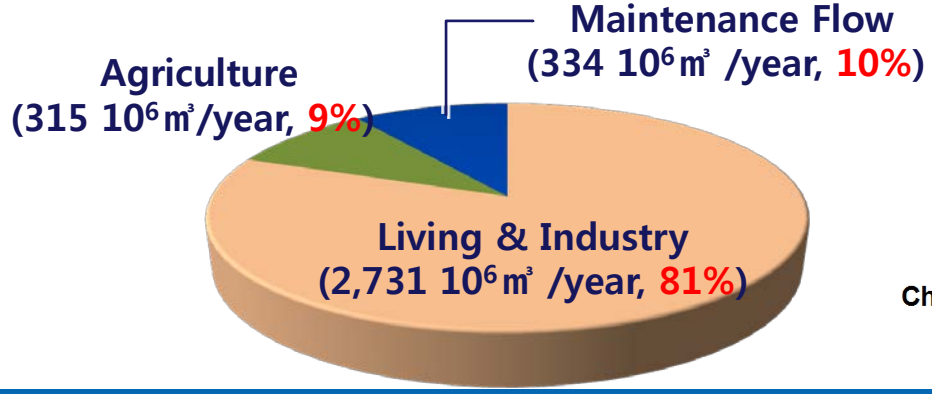
4. Multi-purpose Dam Watershed Description

❑ Chungju Dam & Chungju Regulation Dam Watershed

- ❖ The watershed includes two Dams
- ❖ The study area: 8,245.6 km^2
  - ✓ Forest area ratio: 78.5 % (6,473 km^2)
  - ✓ South Korea : 99,373 km^2
- ❖ The annual average precipitation: 1,450.9 mm
- ❖ The annual mean temperature: 10.3 ℃



➢ Water Supply of CJ Dam



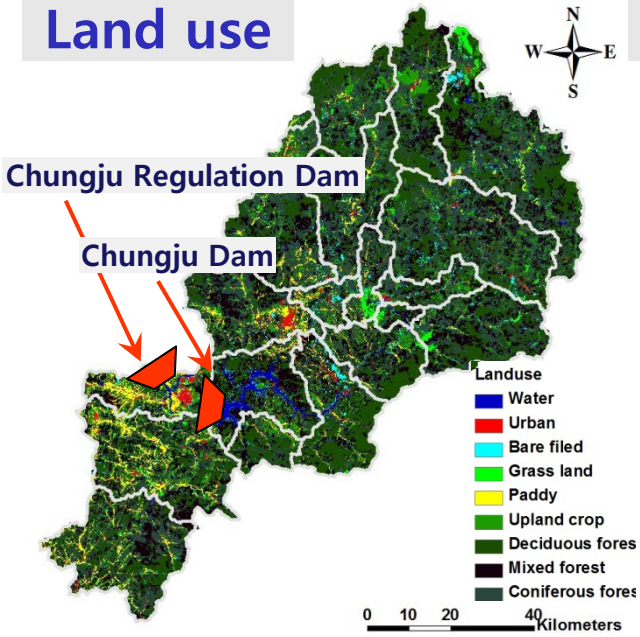
5. Preparation input data

❑ Map data (Land use, soil and elevation data)

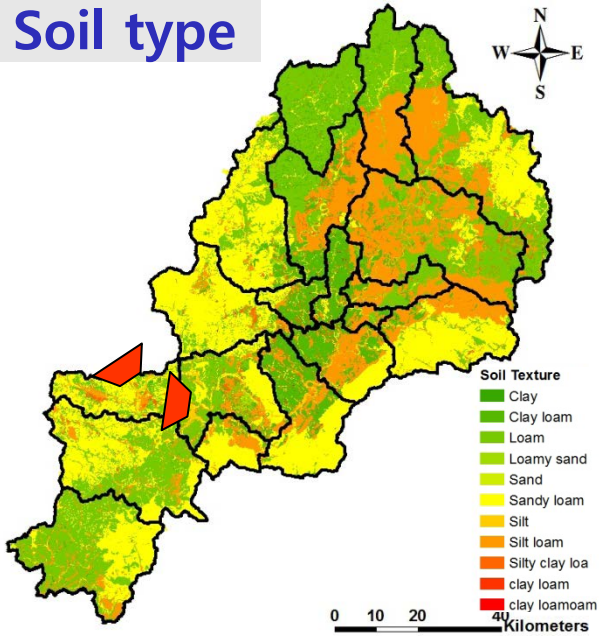
Spatial resolution : 100 m

- ❖ Landuse : Land cover was classified with 9 categories. Forest (78.5%), Upland Crop (11.1%), Paddy (3.6%)
- ❖ Soil Texture : Most soil cover is Sandy Loam (32.3%), Loam (31.8%), and Silty Loam (21.5%) respectively.
- ❖ Average Elevation : 542.8 EL.m

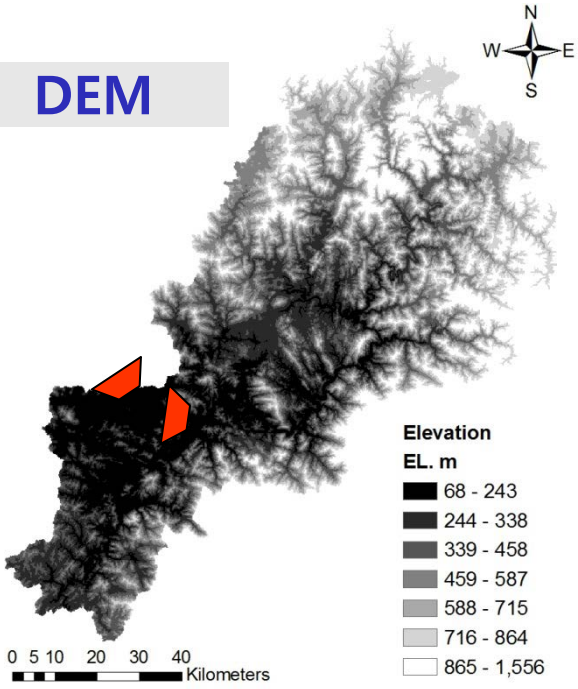
Land use



Soil type

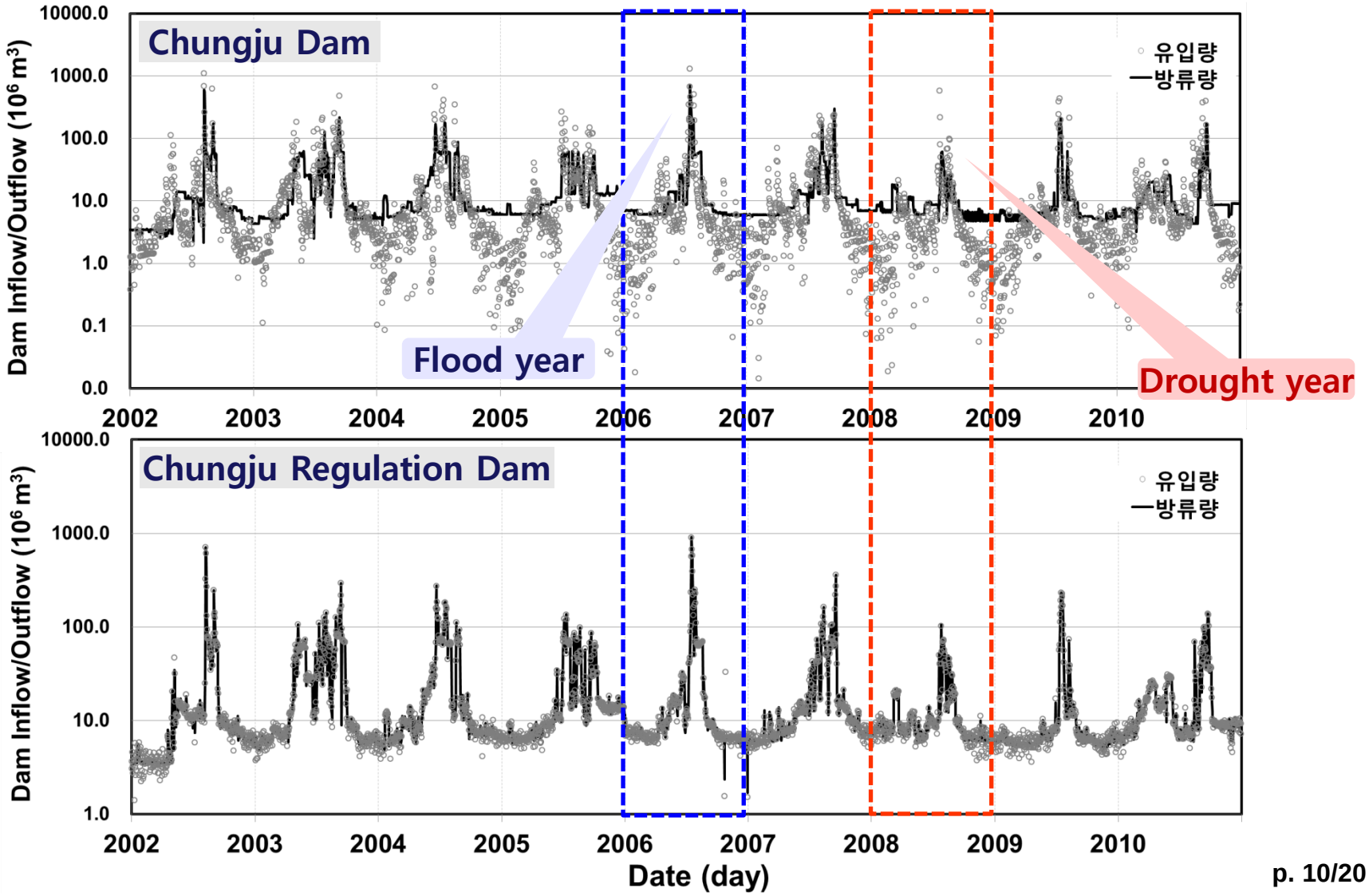


DEM



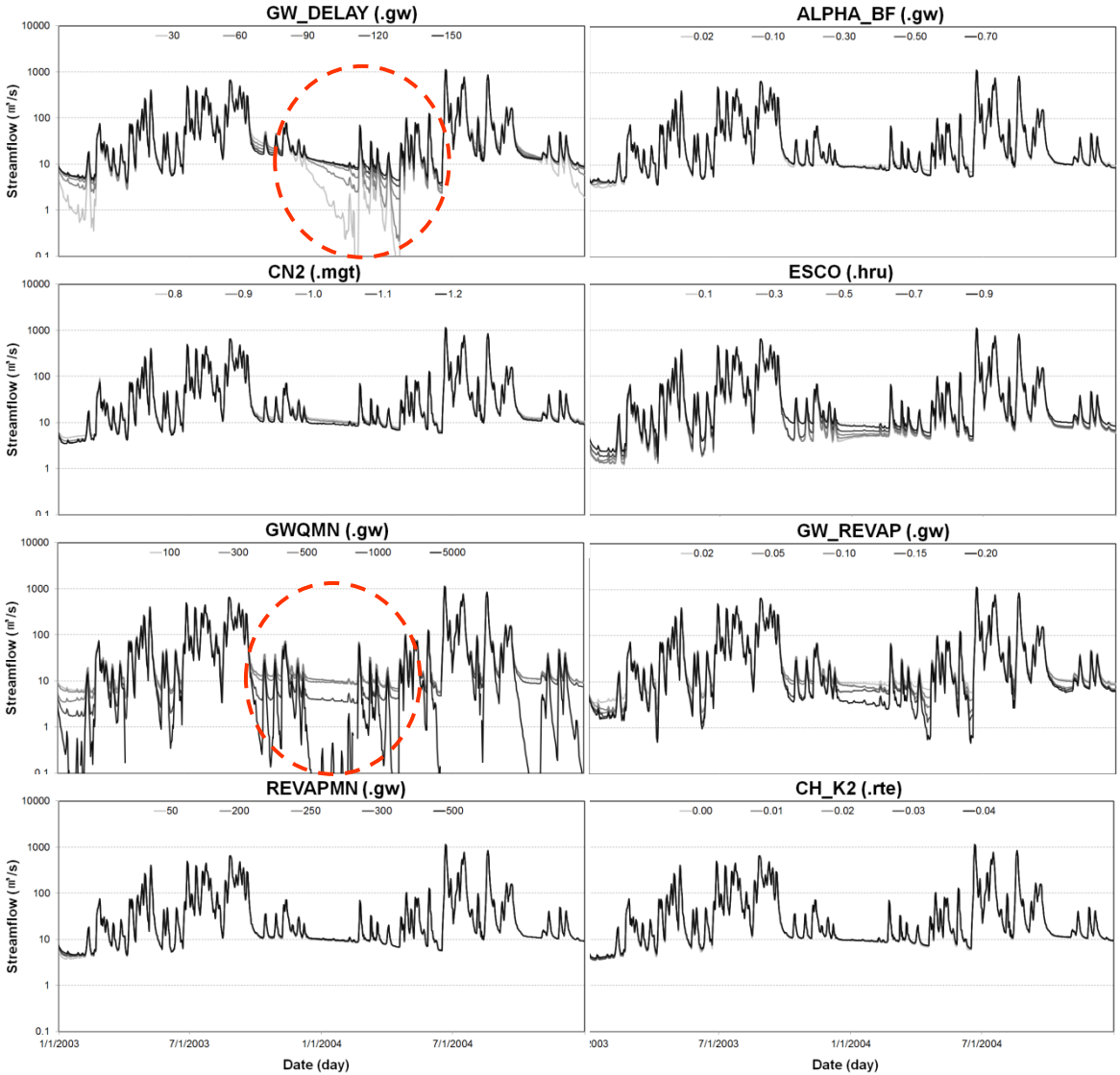
5. Preparation input data - Measured Data

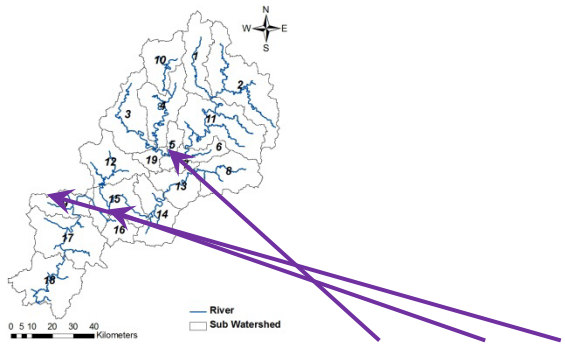
❑ Chungju Dam & Chungju Regulation Dam Inflow / Outflow



6. Model Calibration & Verification - Consider the Dam Operation

❑ Parameter Sensitivity Analysis

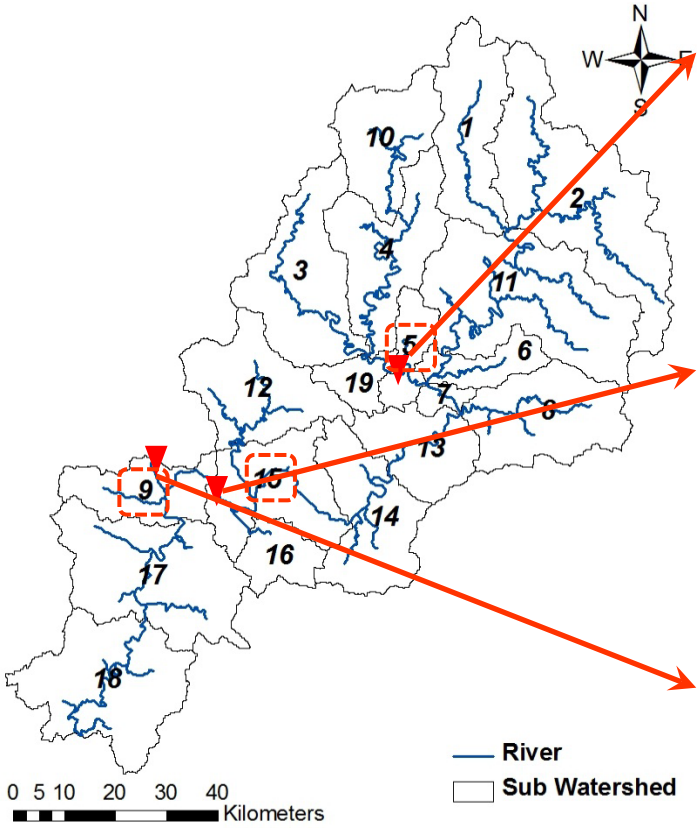


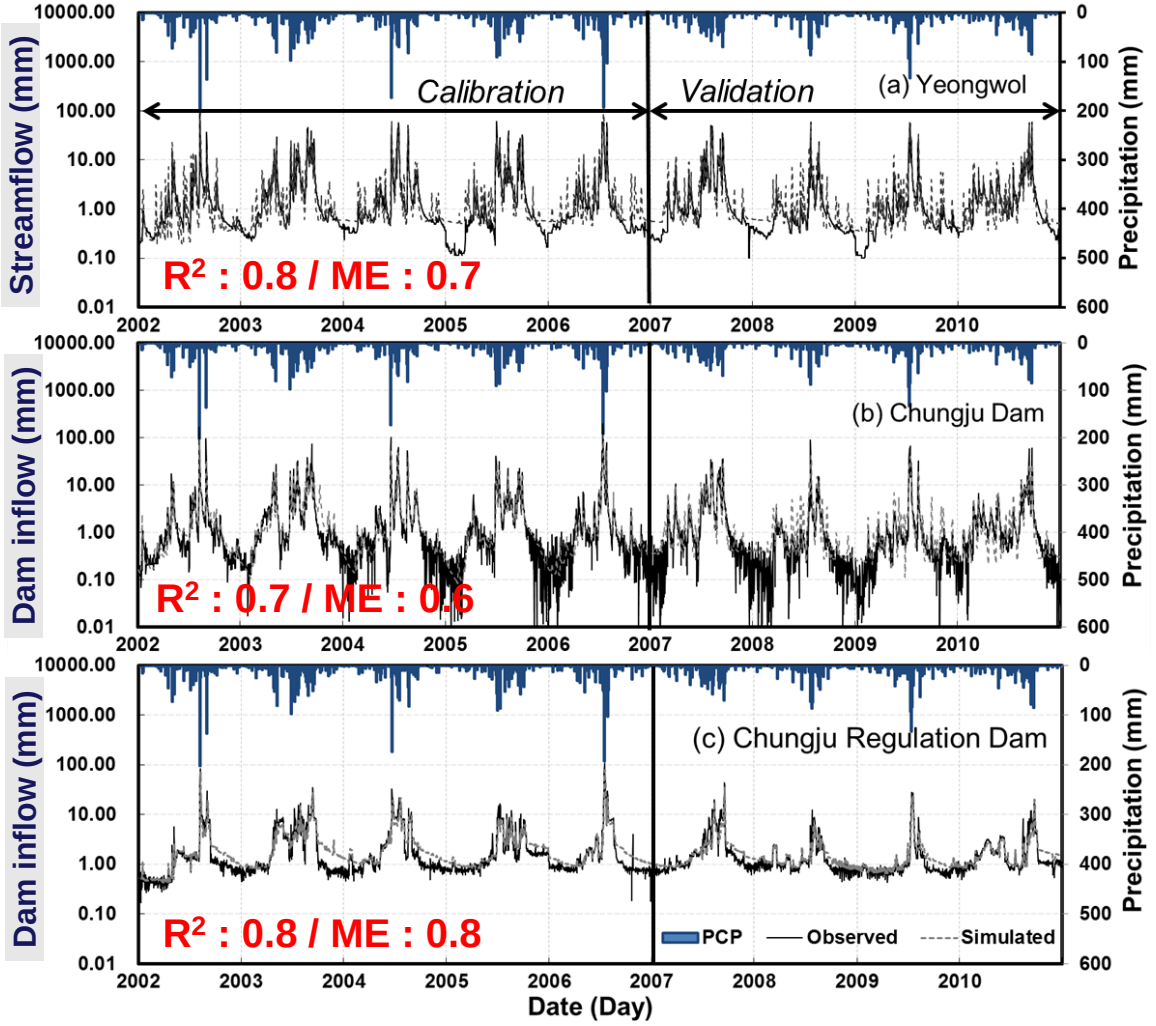


Parameter	Range	YW	CD	CRD
CN2	± 20 %	-10%	-10%	-10%
GWQMN	0 ~ 5000	500	500	250
GW_DELAY	0 ~ 500	300	300	31
GW_REVAP	0.02 ~ 0.2	0.02	0.02	0.2
REVAPMN	0 ~ 500	250	250	200
CH_N	0.01 ~ 0.3	0.016	0.016	0.016
SFTMP	-5 ~ 5	5	5	5
SMTMP	-5 ~ 5	0.5	0.5	0.5
SMFMX	0 ~ 10	1	1	1
SMFMN	0 ~ 10	4.5	4.5	4.5
TIMP	0 ~ 1	1	1	1

6. Model Calibration & Verification - Consider the Dam Operation

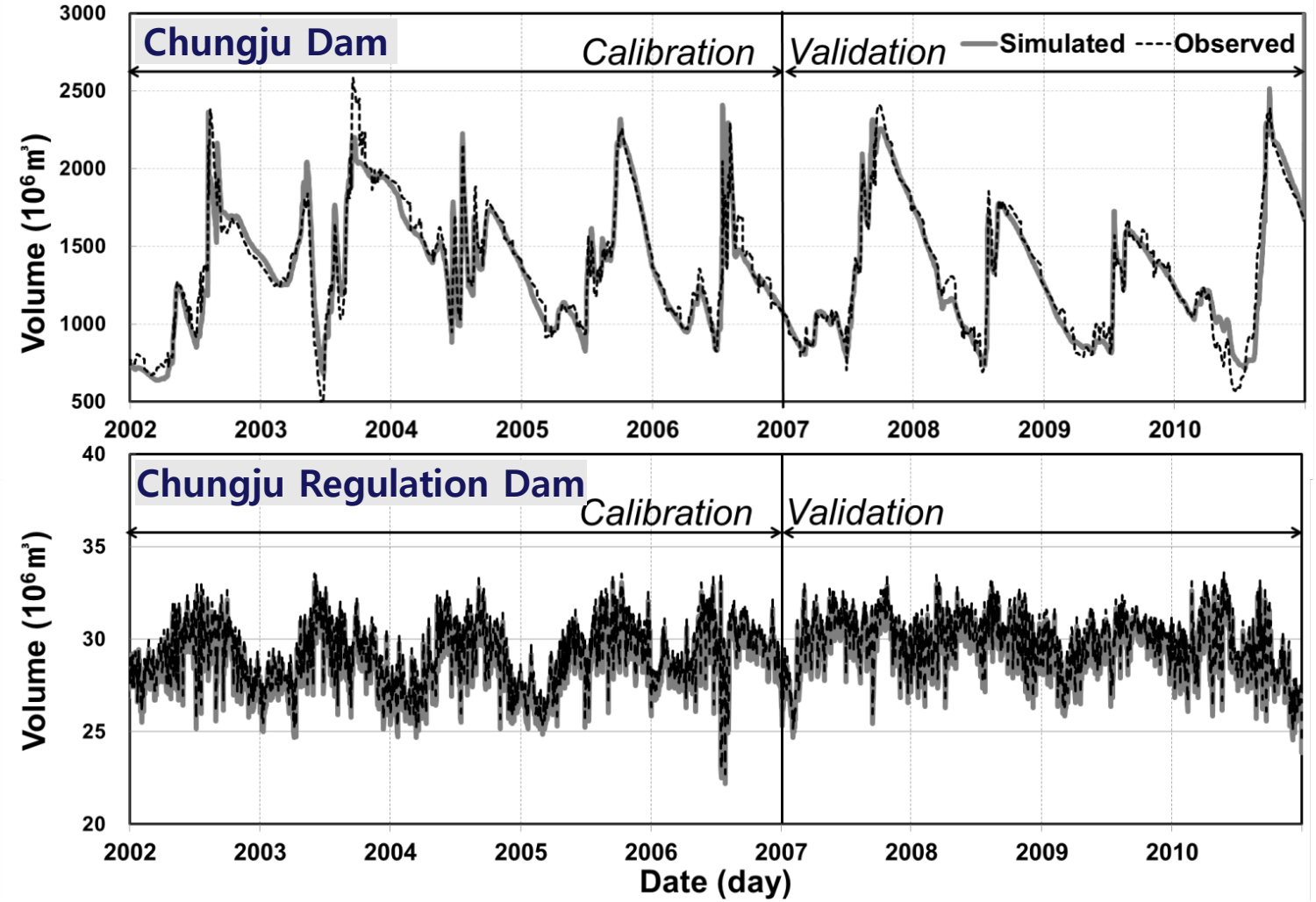
- Calibration period : 2002–2006 / Verification period : 2007–2010





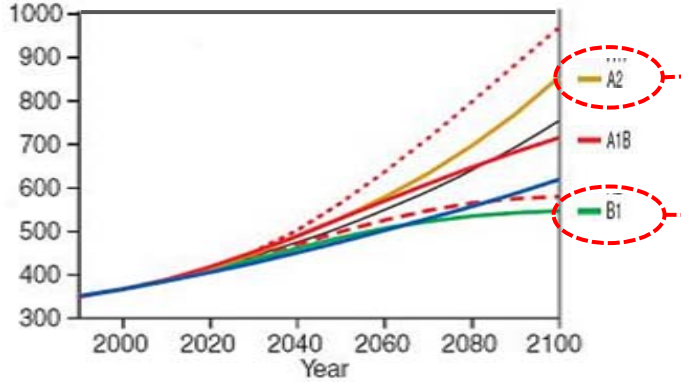
6. Model Calibration & Verification - Consider the Dam Operation

❑ Calibration & Verification of Dam Volume

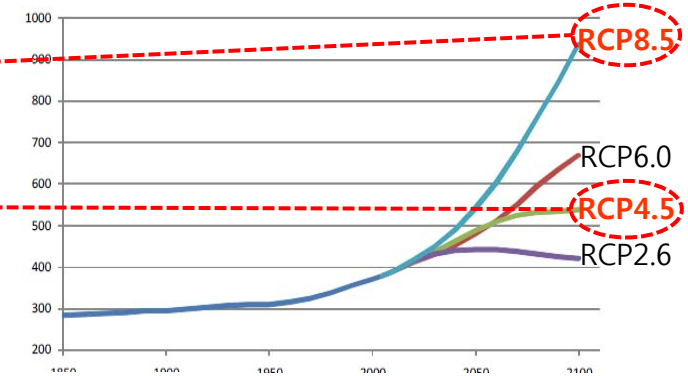


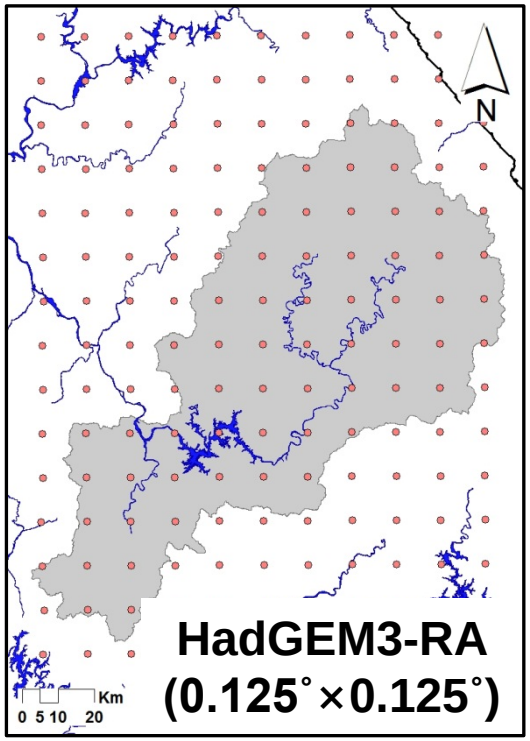
7. Application of RCP scenarios

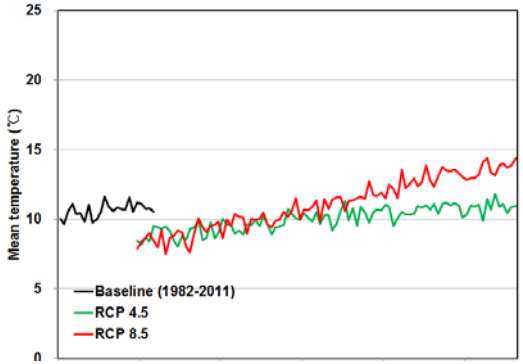
SRES
(Special Report on Emission Scenario)

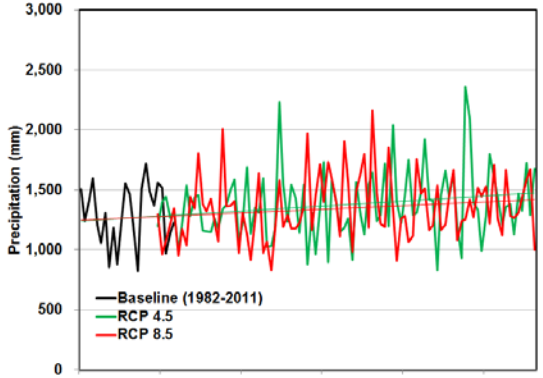


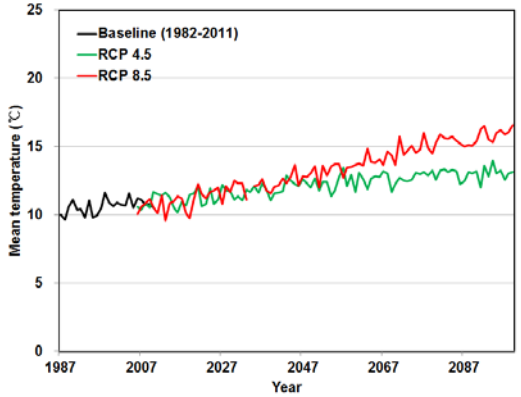
RCP Scenario
(Representative Concentration Pathway)

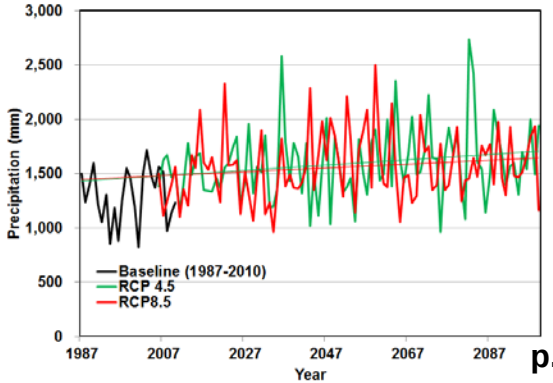








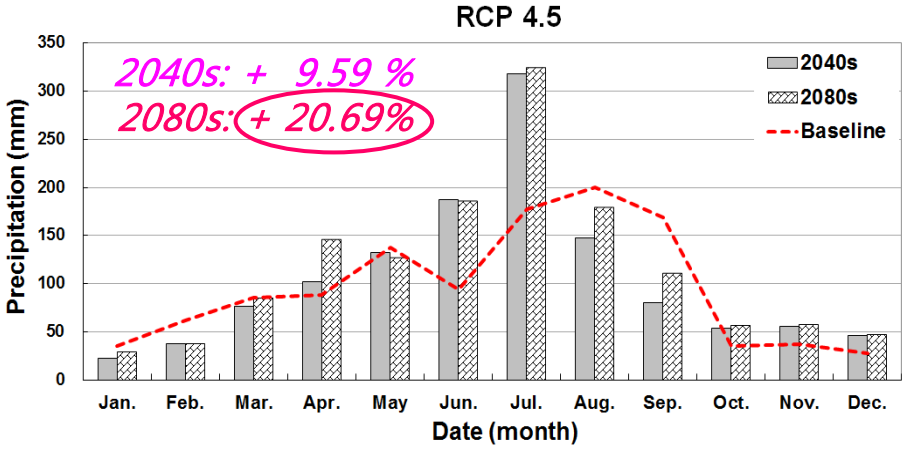


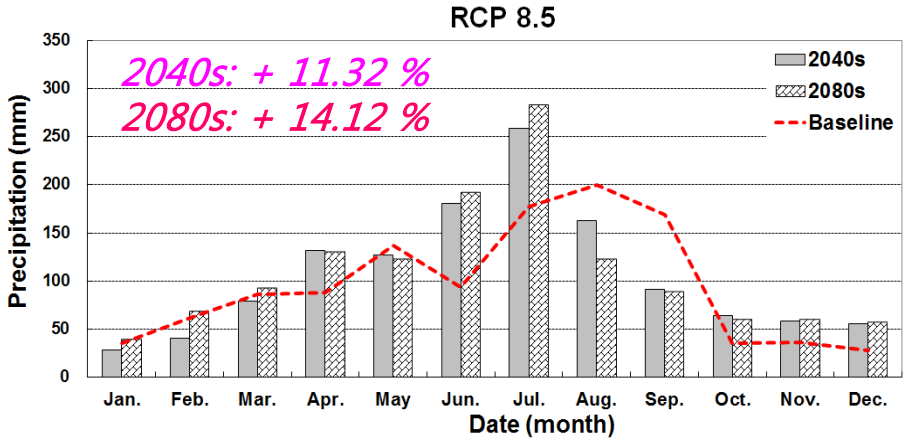


7. Application of RCP scenarios

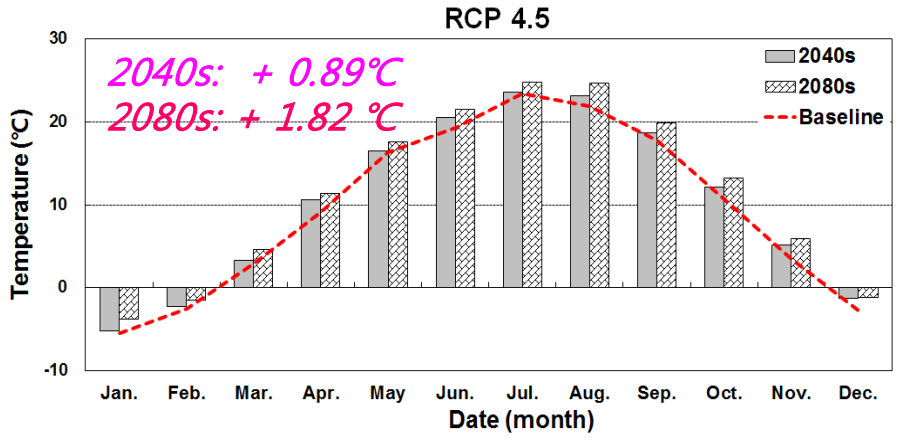
Baseline : 2002~2010 / 2040s : 2031~2050 / 2080s : 2071~2090

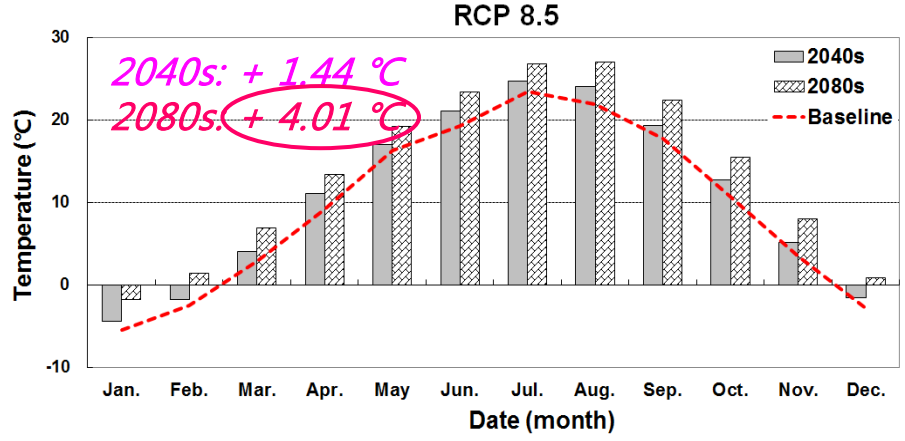
Precipitation (mm)





Temperature (℃)





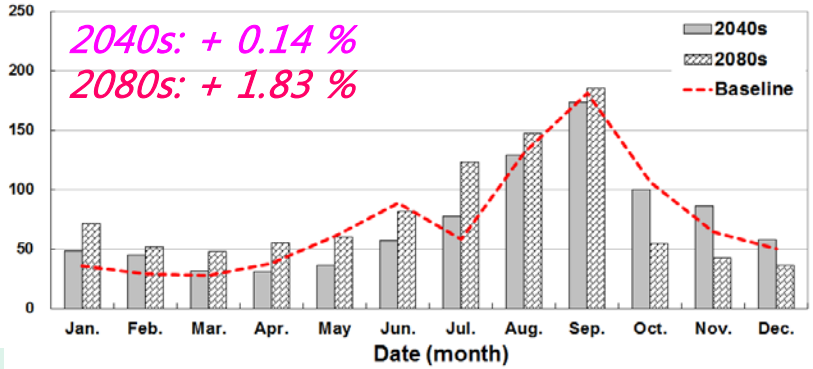
7. Application of RCP scenarios

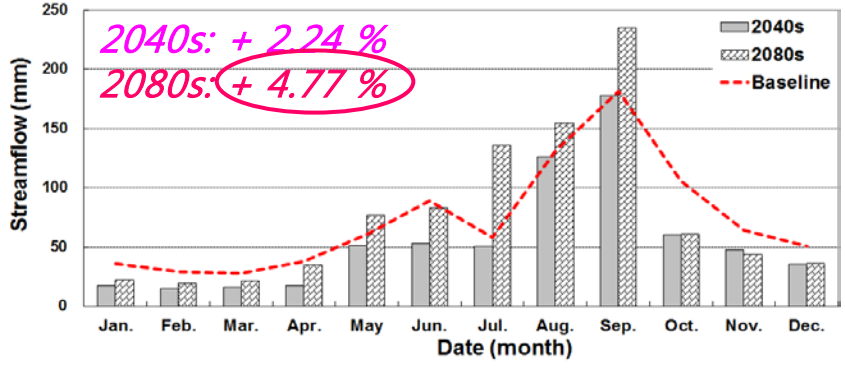
Baseline : 2002~2010 / 2040s : 2031~2050 / 2080s : 2071~2090

RCP 4.5

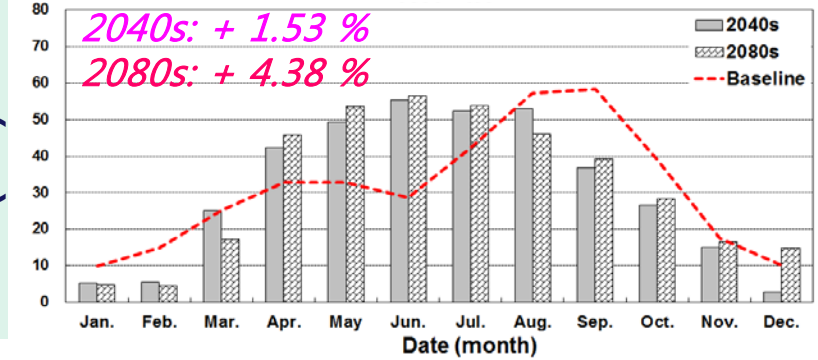
RCP 8.5

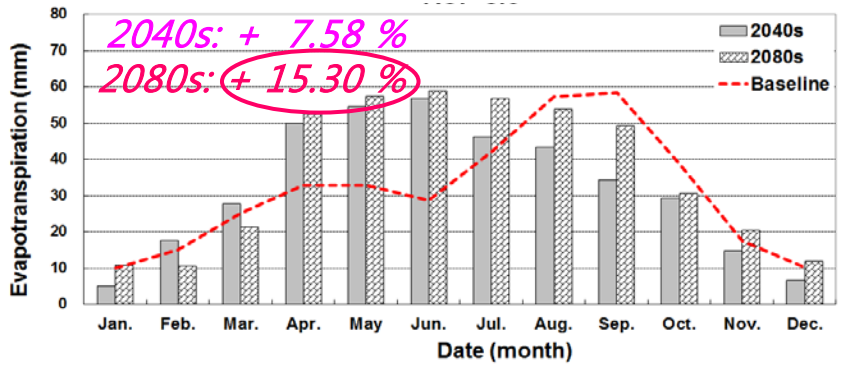
Dam inflow (mm)



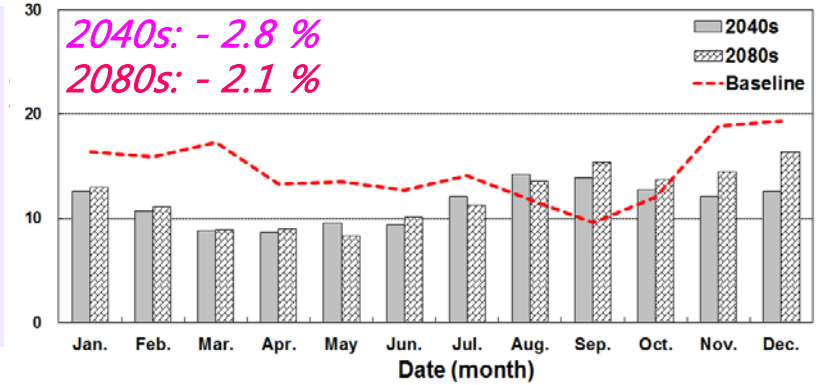


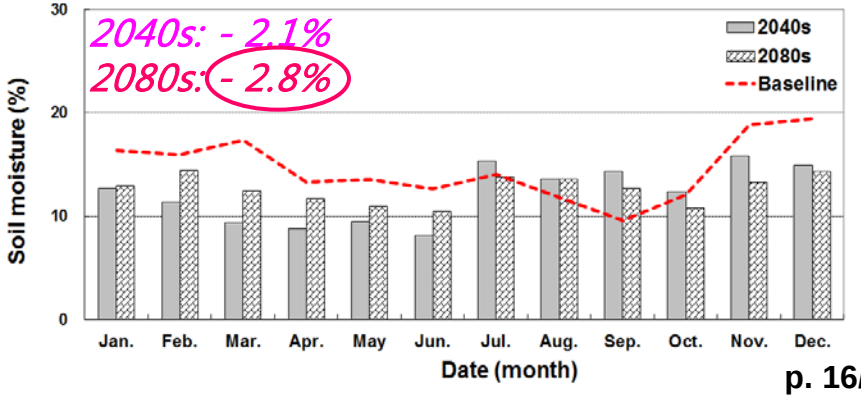
Evapotranspiration (mm)





Soil moisture (%)

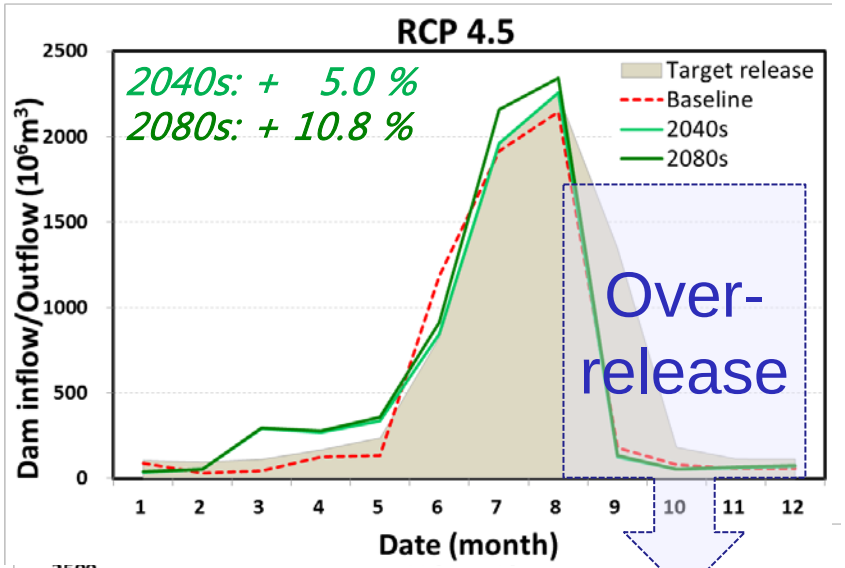


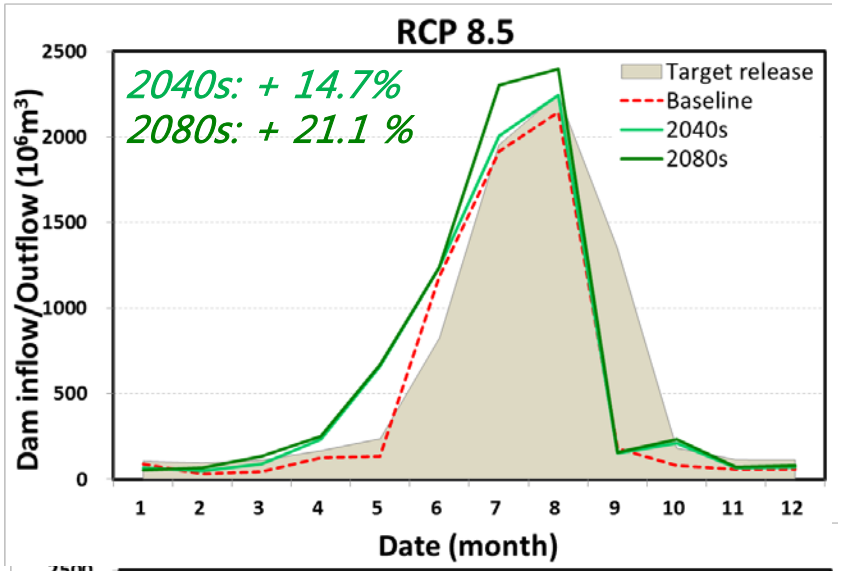


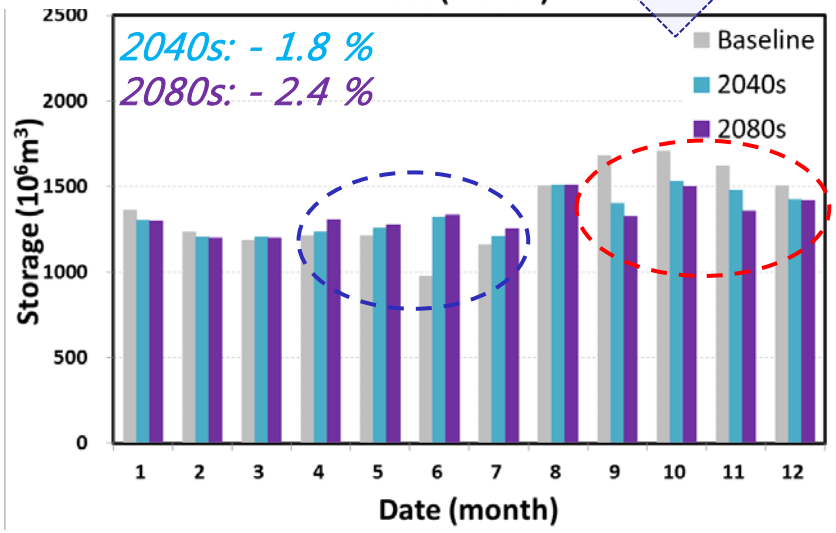
7. Assessment of Future Dam Operation

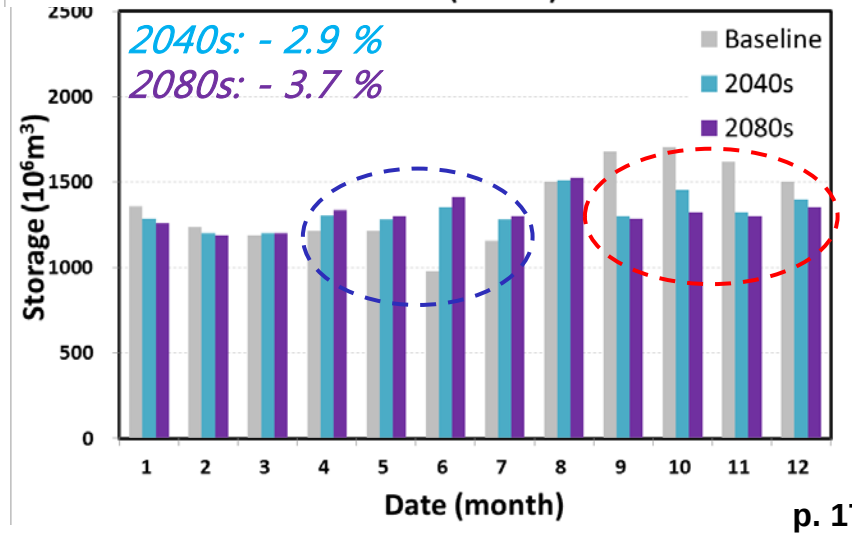
Baseline : 2002~2010 / 2040s : 2031~2050 / 2080s : 2071~2090

Climate Change Impact on Dam inflow and Storage (CJ)





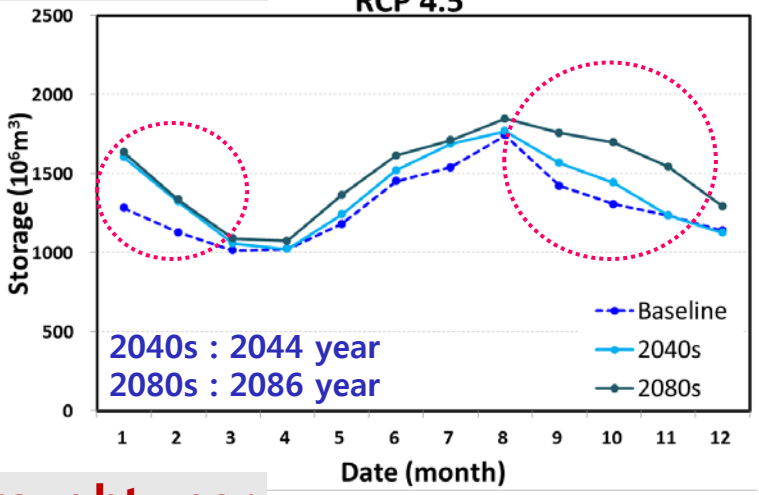


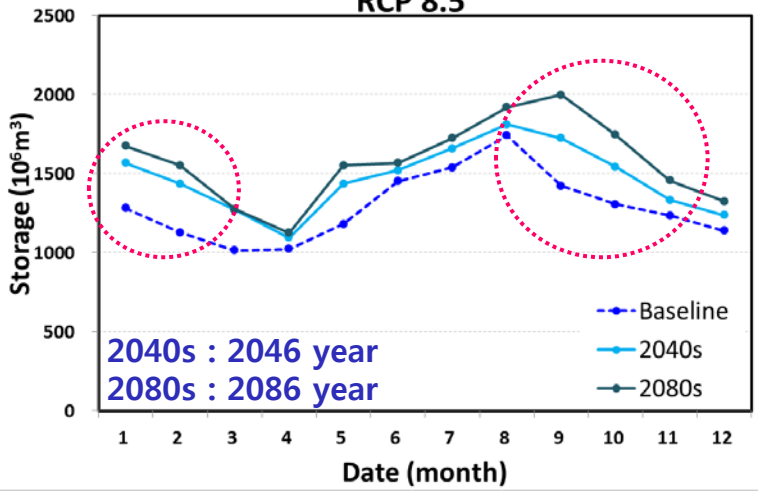


7. Assessment of Future Dam Operation

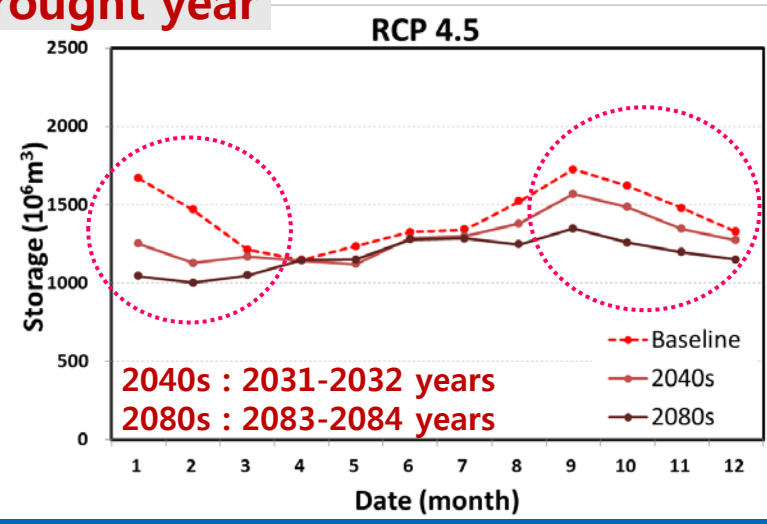
Future Dam Storage of Flood year and Drought year (CJ)

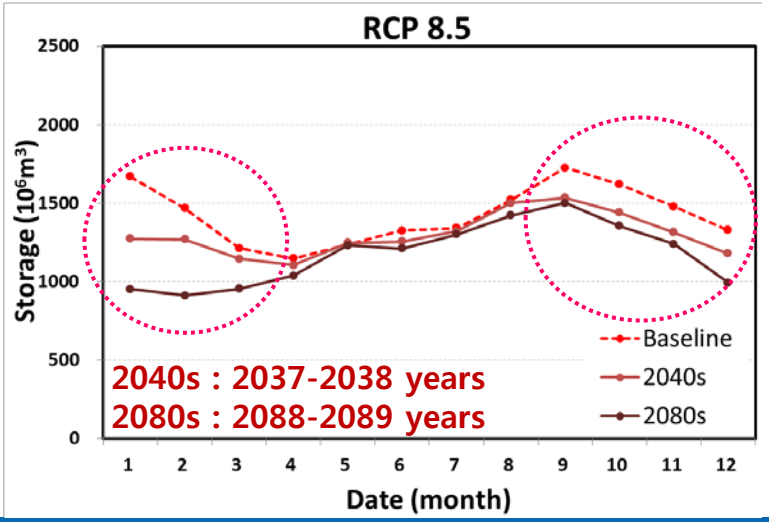
Flood year





Drought year

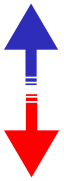




Summary & Concluding remarks

- The availability of downstream maintenance flow from multipurpose dam was evaluated under the RCP climate change scenarios using SWAT dam operation.

- In the future,
  - ✓ **Dam storage** (under the present monthly target release)
    - Increased in **s**pring and **s**ummer → Available
    - Decreased in **a**utumn and **w**inter → Shortage



- *So, we need the adjustment of operation rule for seasonal target release in a monthly base by the temporal variations of dam storage.*

“ Thank You ”

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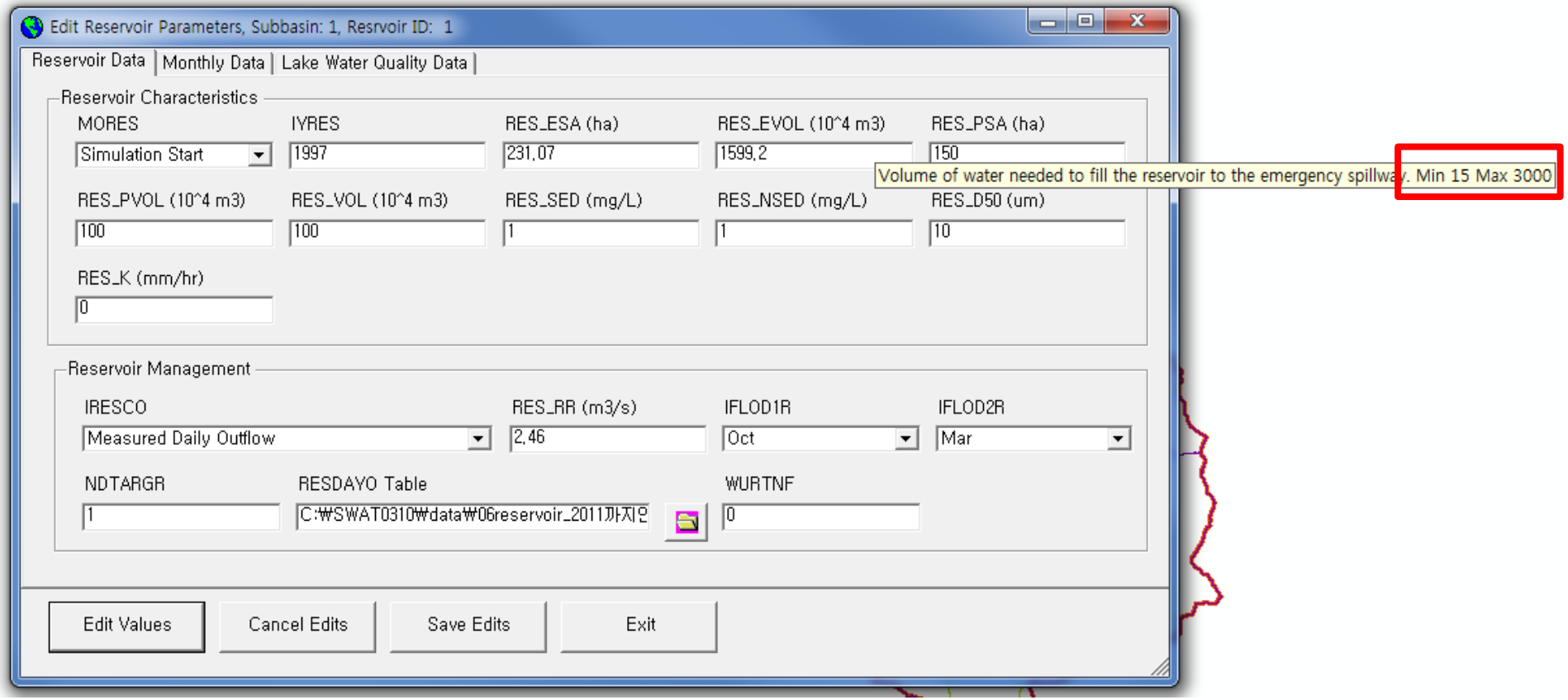
See us at:

http://konkuk.ac.kr/~kimsj/

Earth Information Engineering Laboratory

Q & A

ArcSWAT


Edit Reservoir Parameters, Subbasin: 1, Resrvoir ID: 1
Reservoir Data
Monthly Data
Lake Water Quality Data
Reservoir Characteristics
MORES
Simulation Start
IYRES
1997
RES_ESA (ha)
231.07
RES_EVOL (10^4 m3)
1599.2
RES_PSA (ha)
150
Volume of water needed to fill the reservoir to the emergency spillway. Min 15 Max 3000
RES_PVOL (10^4 m3)
100
RES_VOL (10^4 m3)
100
RES_SED (mg/L)
1
RES_NSED (mg/L)
1
RES_D50 (um)
10
RES_K (mm/hr)
0
Reservoir Management
IRESCO
Measured Daily Outflow
RES_RR (m3/s)
2.46
IFLOD1R
Oct
IFLOD2R
Mar
NDTARGR
1
RESDAYO Table
C:₩SWAT0310₩data₩06reservoir_2011까지오
WURTNF
0
Edit Values
Cancel Edits
Save Edits
Exit

AVSWAT-X, V4.11 (with ArcView 3.2)

Watershed	IYRES (Year)	RES_ESA (ha)	RES_EVOL ($10^4 m^3$)	RES_PSA (ha)	RES_PVOL ($10^4 m^3$)	RES_VOL ($10^4 m^3$)	RES_K (mm/hr)
CJ Dam	2002	9634	261951	8775	225152	74211.5	0.5
CJR Dam	2002	1194	5585	851	3373	2749.5	0.1