Using SWAT for Estimating Impact of Sediment and Pollutant Export in the Chungju Dam Watershed, Korea

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Contents

- ***Background & Objectives***
- ***SWAT model application***
- ***Estimation of transmission characteristics***
- ***Assessing impact of sediment & nutrient export***
- ***Conclusions***

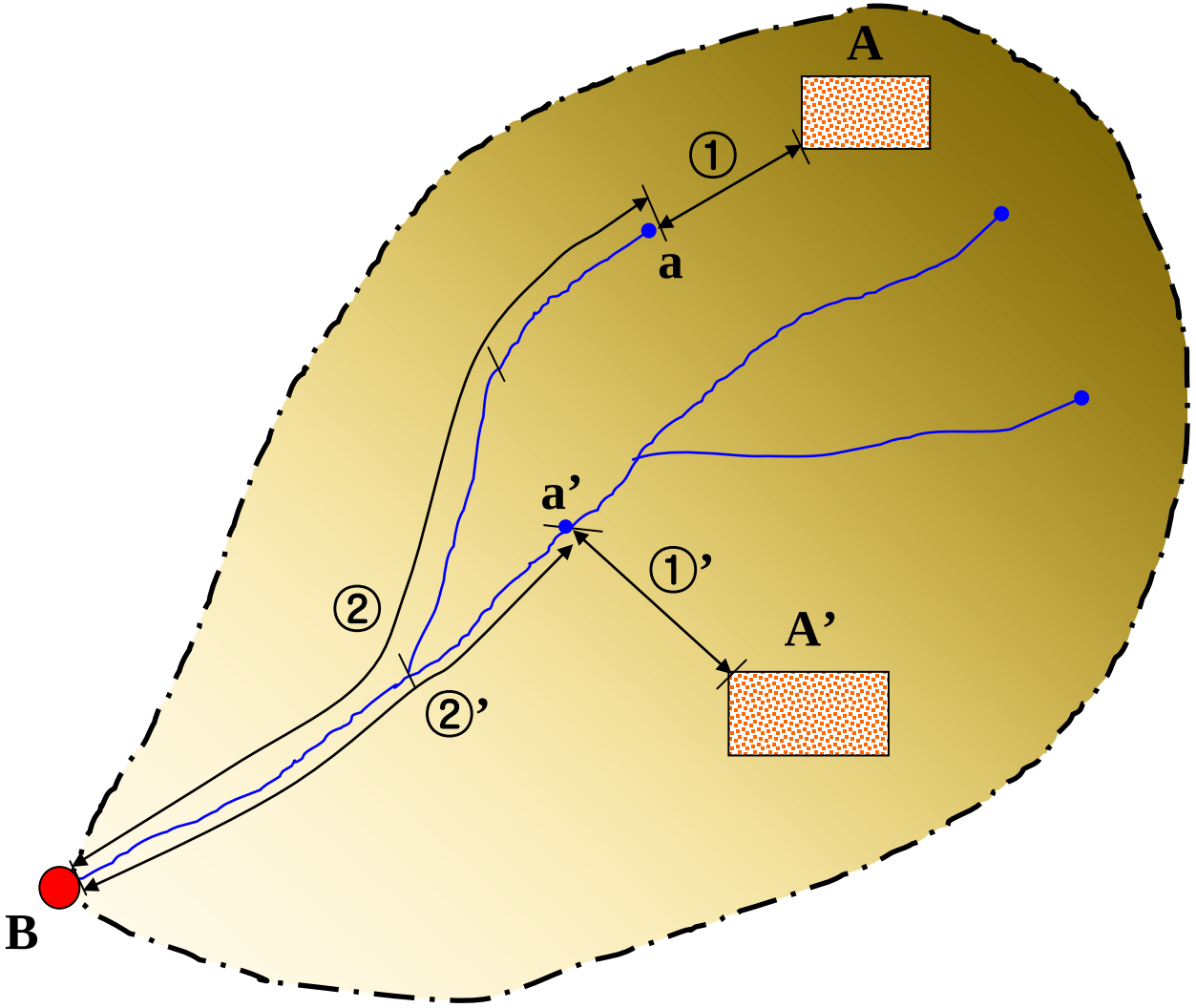
Background

- *The total Maximum Daily Load(TMDL) program has been performed for the Geum River, Yeongsan River, Seomjin River, and some areas of the Han River of Korea since August of 2004 starting on the Nakdong River basin.*
- *TMDLs are quantitative objectives and strategies needed to achieve water quality standards, which can be implemented by controlling the discharged loads from the upstream areas.*
- *To decide the way and the amount of discharged loads to be reduced, it is necessary to accurately estimate the impact of the loads from the upstream areas on the water quality standards at the downstream point of interest.*

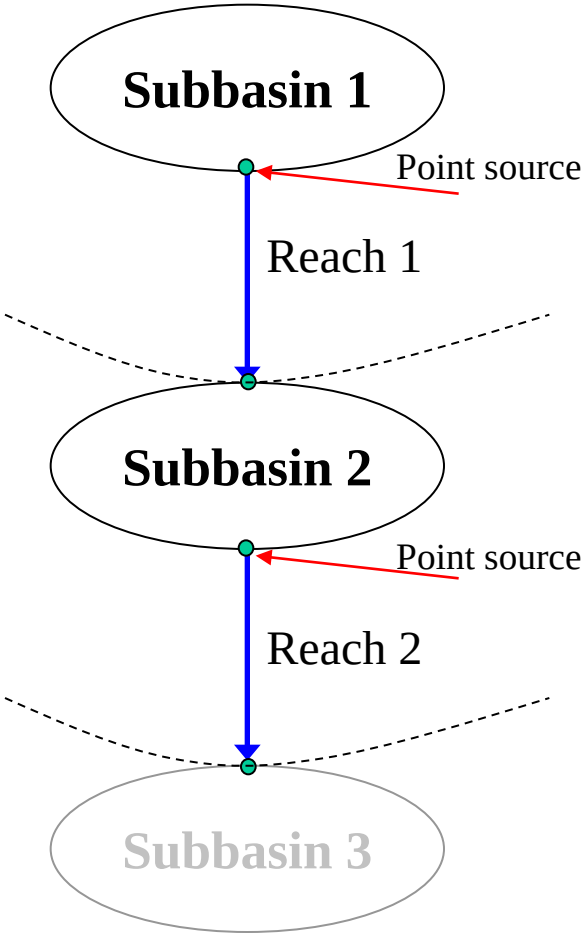
Objectives are

- *Simulating the discharged pollutants to stream reaches such as sediment, nitrogen, and phosphorus*
- *Quantitatively estimating how much the pollutants are delivered to the downstream point of interest and actually contribute the total loads at the Chungju Dam*

Pollutant transport in a watershed



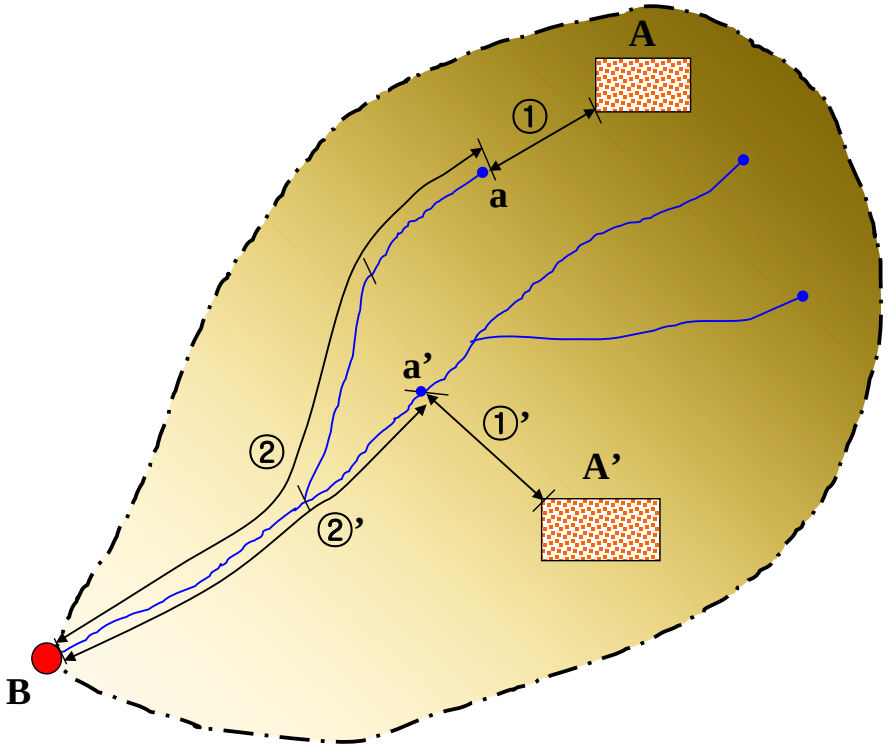
Pollutant transport in SWAT



Surface flow, lateral flow, groundwater flow, sediment yield, nutrient yield, …

Main channel routing

- Flow : Muskingum
- Sediment : degradation or deposition by transport capacity
- Nutrients : QUAL2E algorithm



Transmission ratio

Transmission loss (USDA NRCS, 2001)

"A reduction in volume of flow in a stream, canal, or other waterway, due to infiltration or seepage into the channel bed and banks."

focused on decrease of water volume

extend to the sediment and pollutants

Definition of "Transmission Ratio"

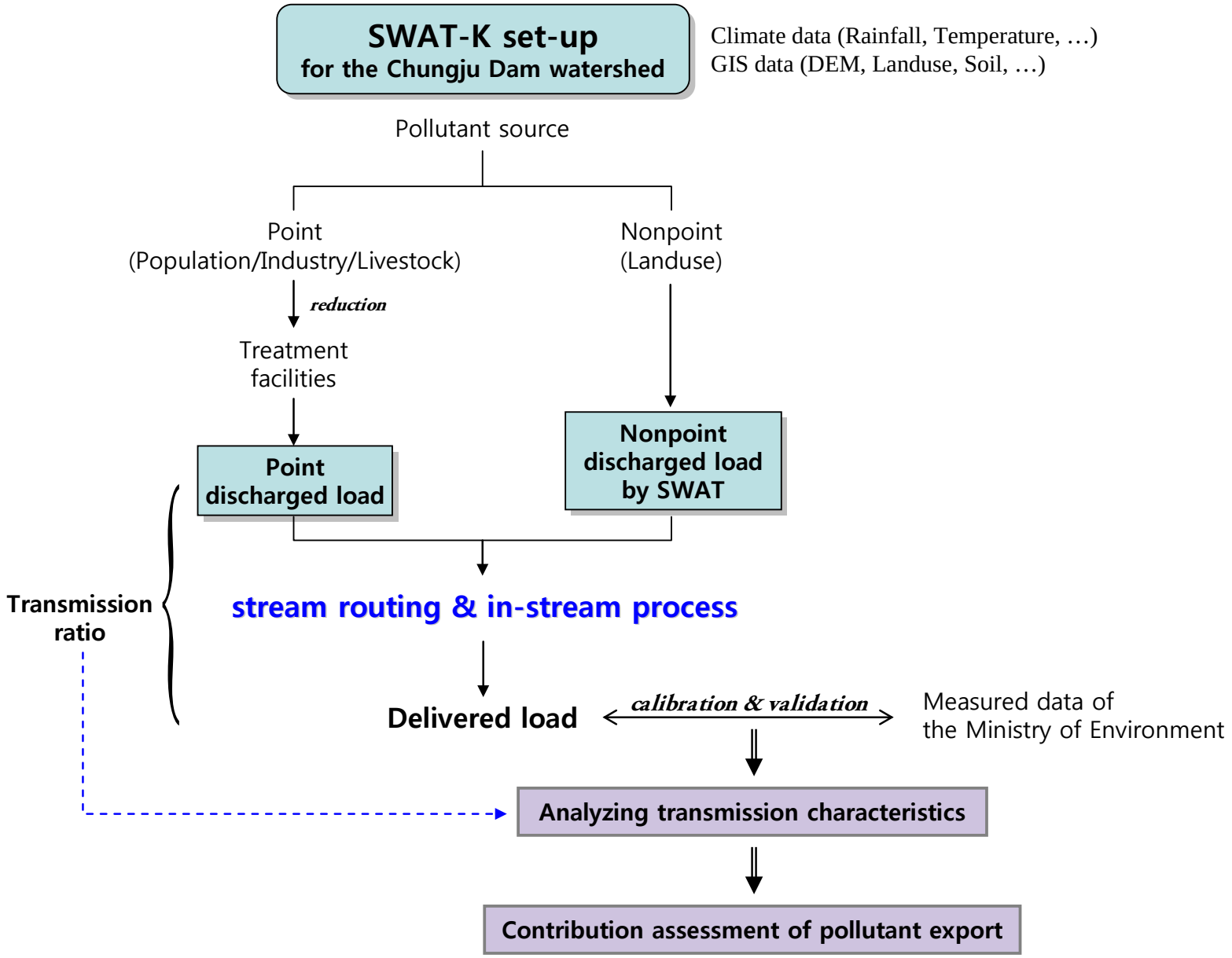
→ the ratio of the delivered load to a downstream reach to the discharged load into a upstream reach

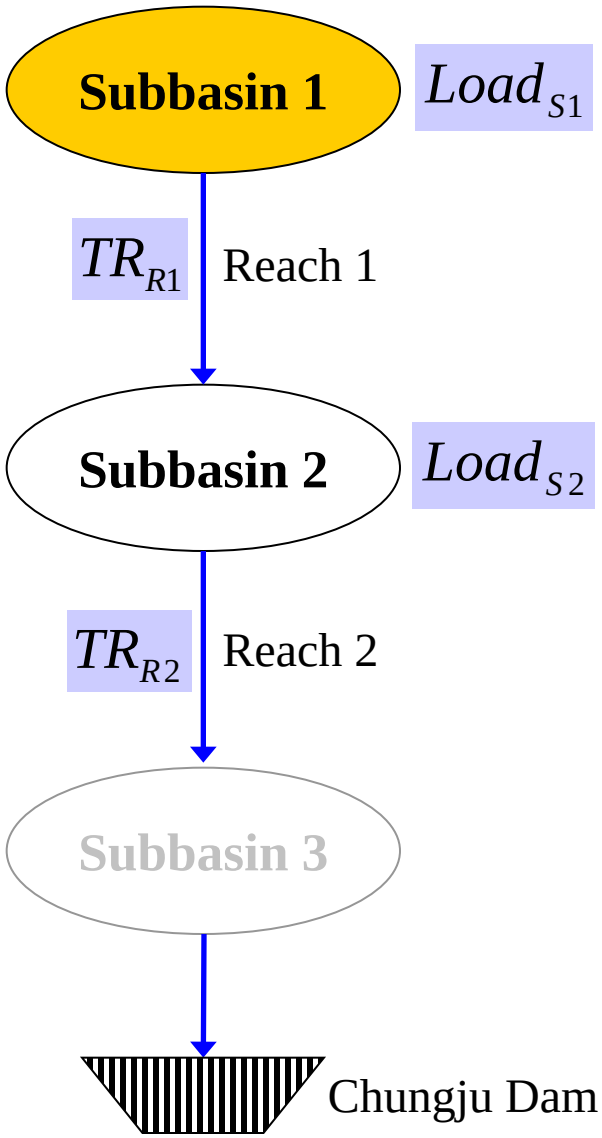
→ a decrease or an increase of sediment and pollutant loads by degradation or deposition, and in-stream nutrient transport processes through streams

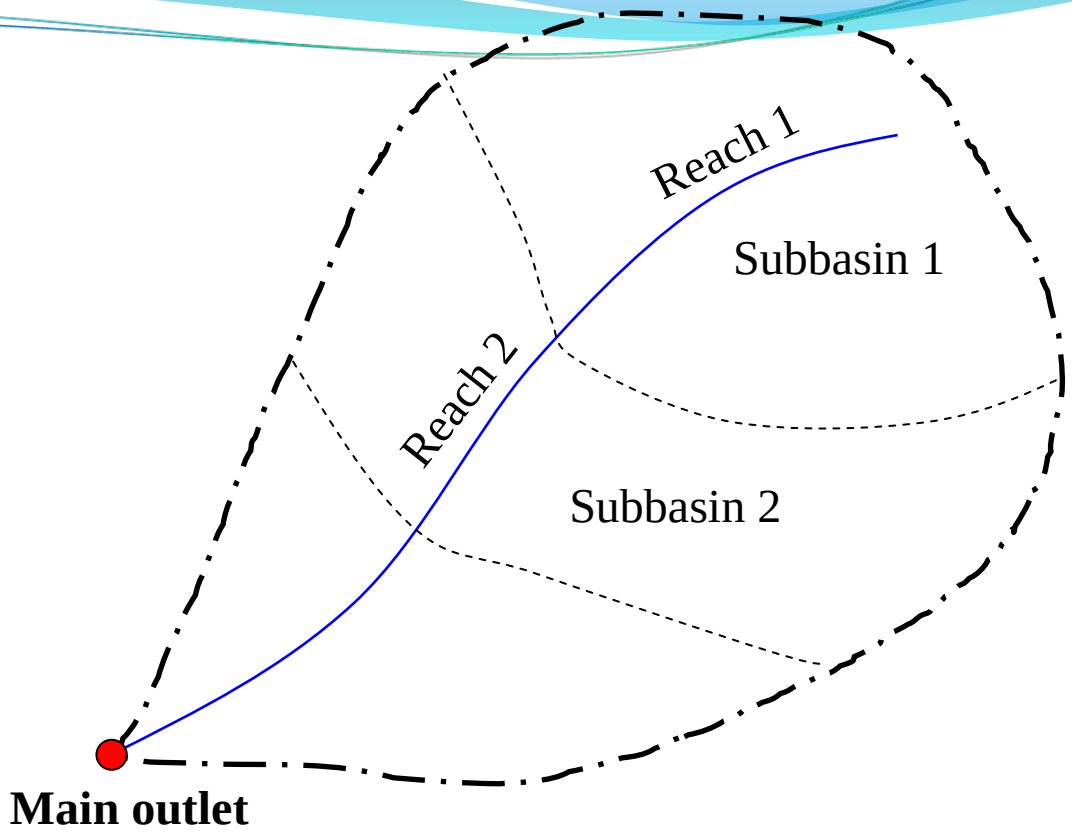
$$TR = f(Load_{in},\ QUAL2E\ \ reaction\ \ coefficients, \ldots)$$

Rainfall-Runoff processes

Methodological approach



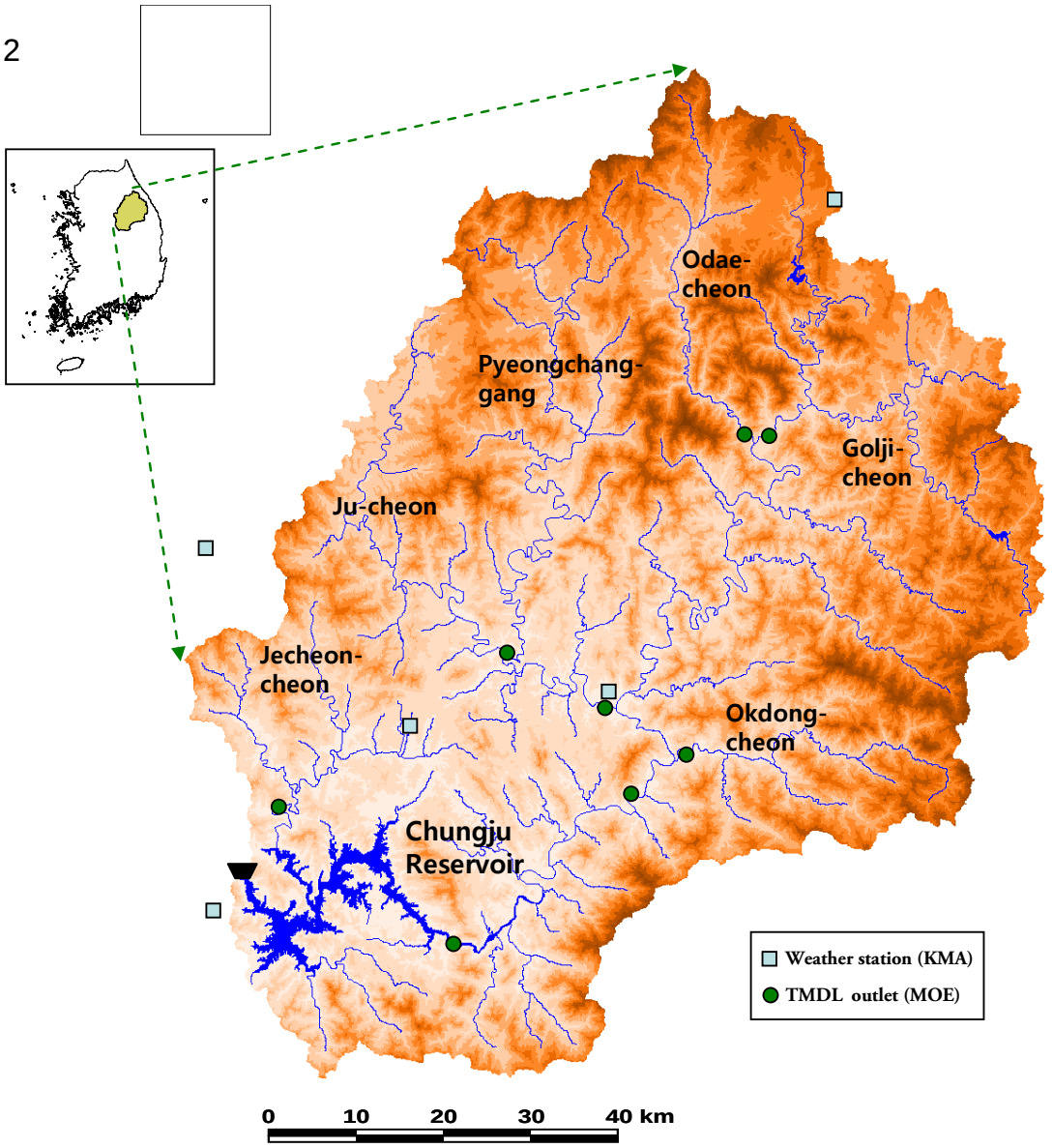




$$Dam.Load_{S1\_in} = Load_{S1} \times TR_{R1} \times TR_{R2} \times \ldots$$

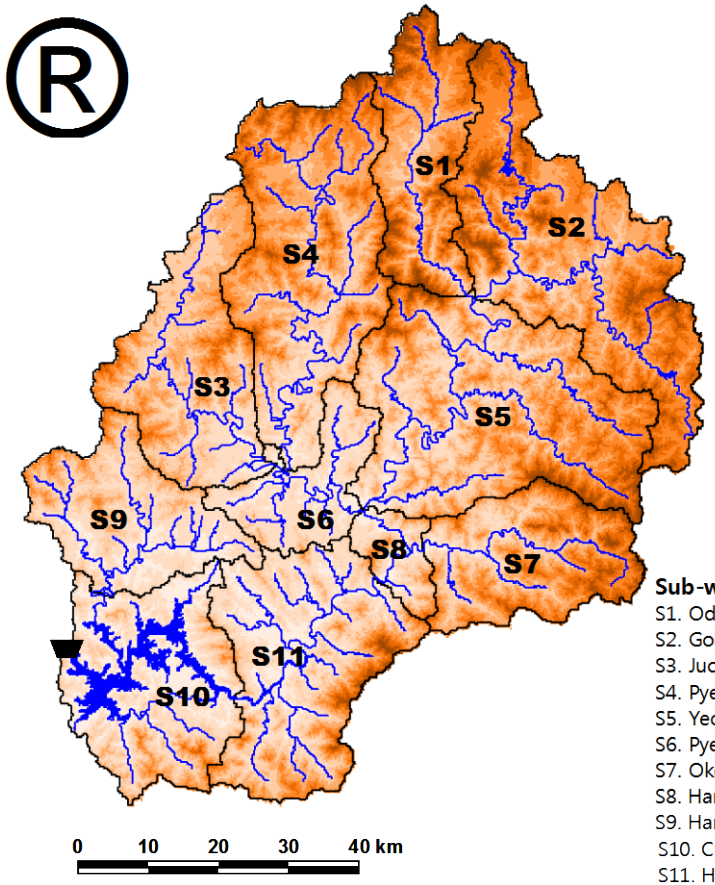
Chungju Dam watershed

Drainage area : 6,648 km^2

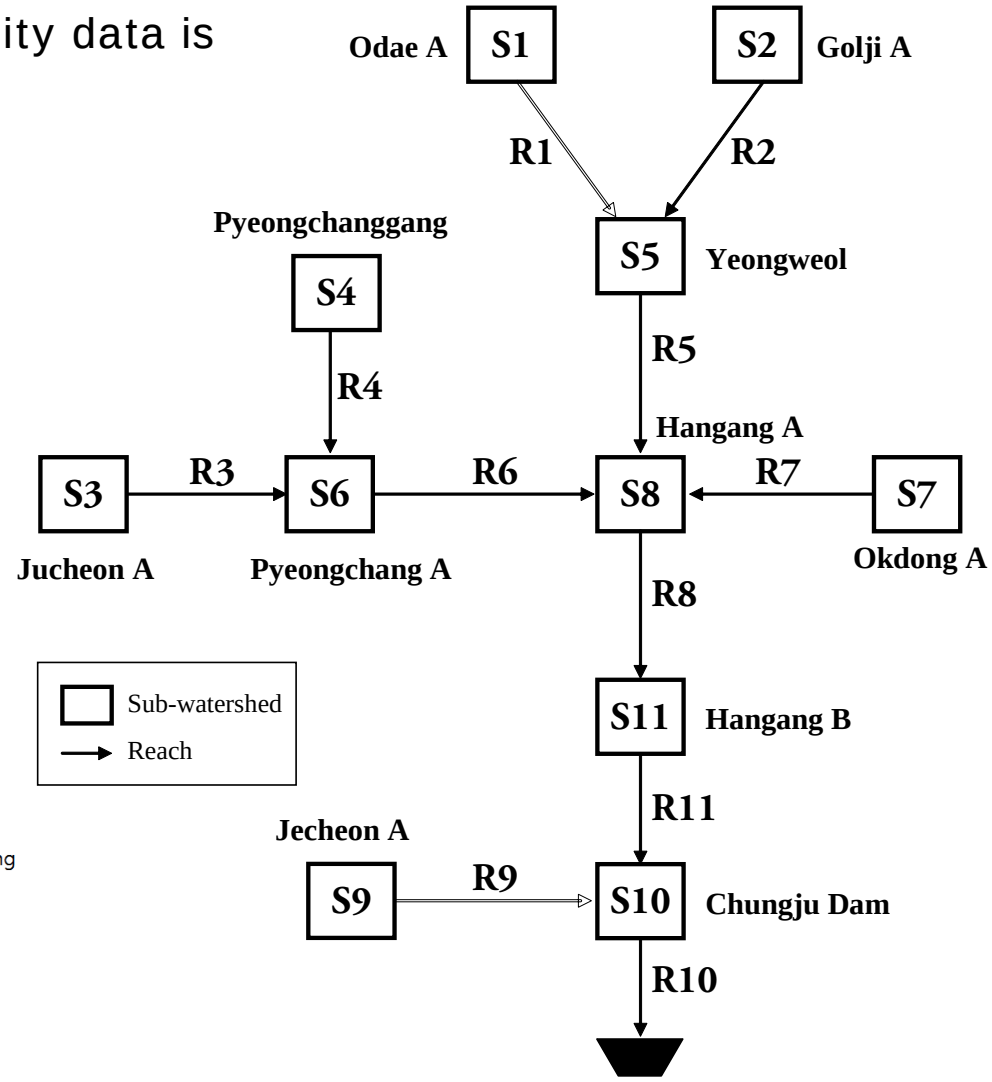


Sub-watershed & reach

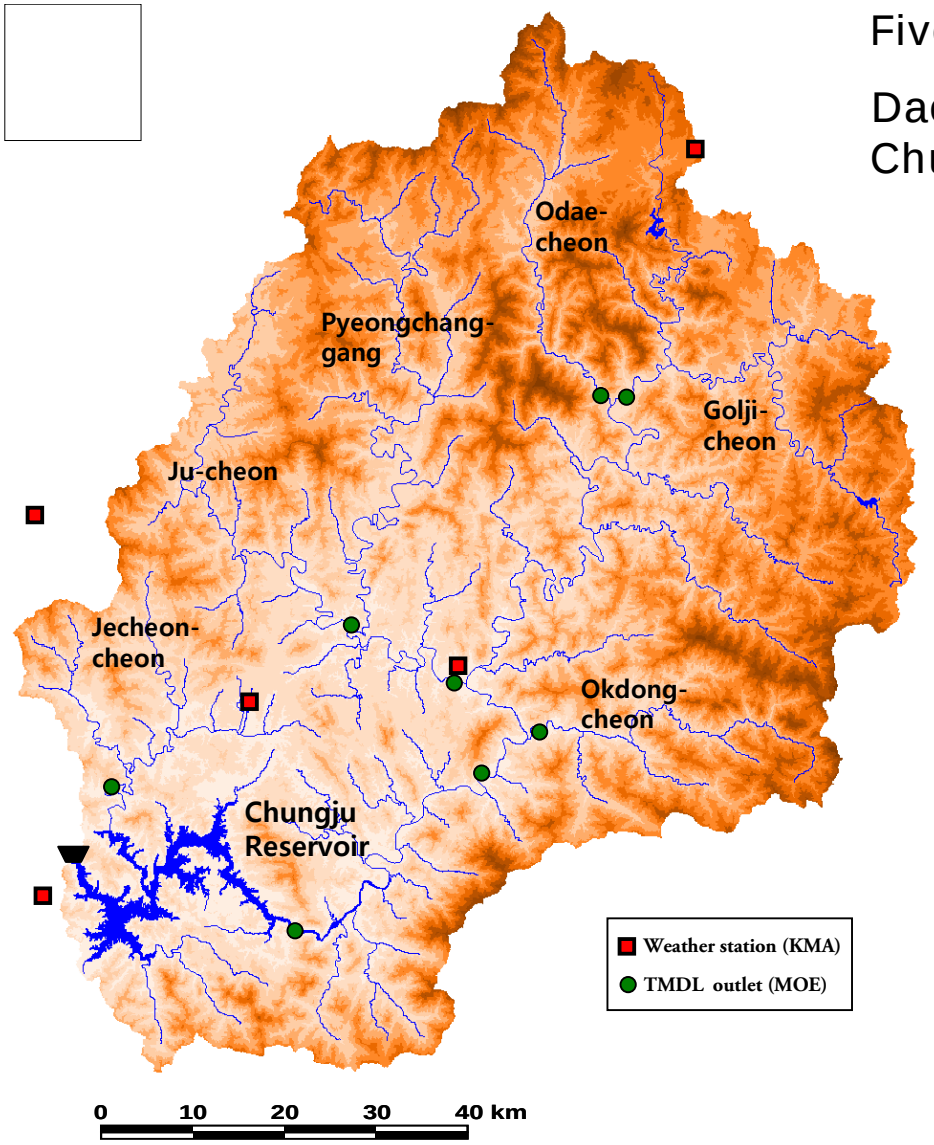
The watershed is divided to 11 sub-watersheds where the hydrologic or water quality data is monitored



Sub-watersheds
S1. Odae A
S2. Golji A
S3. Jucheon A
S4. Pyeongchanggang
S5. Yeongweol
S6. Pyeongchang A
S7. Okdong A
S8. Hangang A
S9. Hangang B
S10. Chungju Dam
S11. Hangang B



Model input : weather data



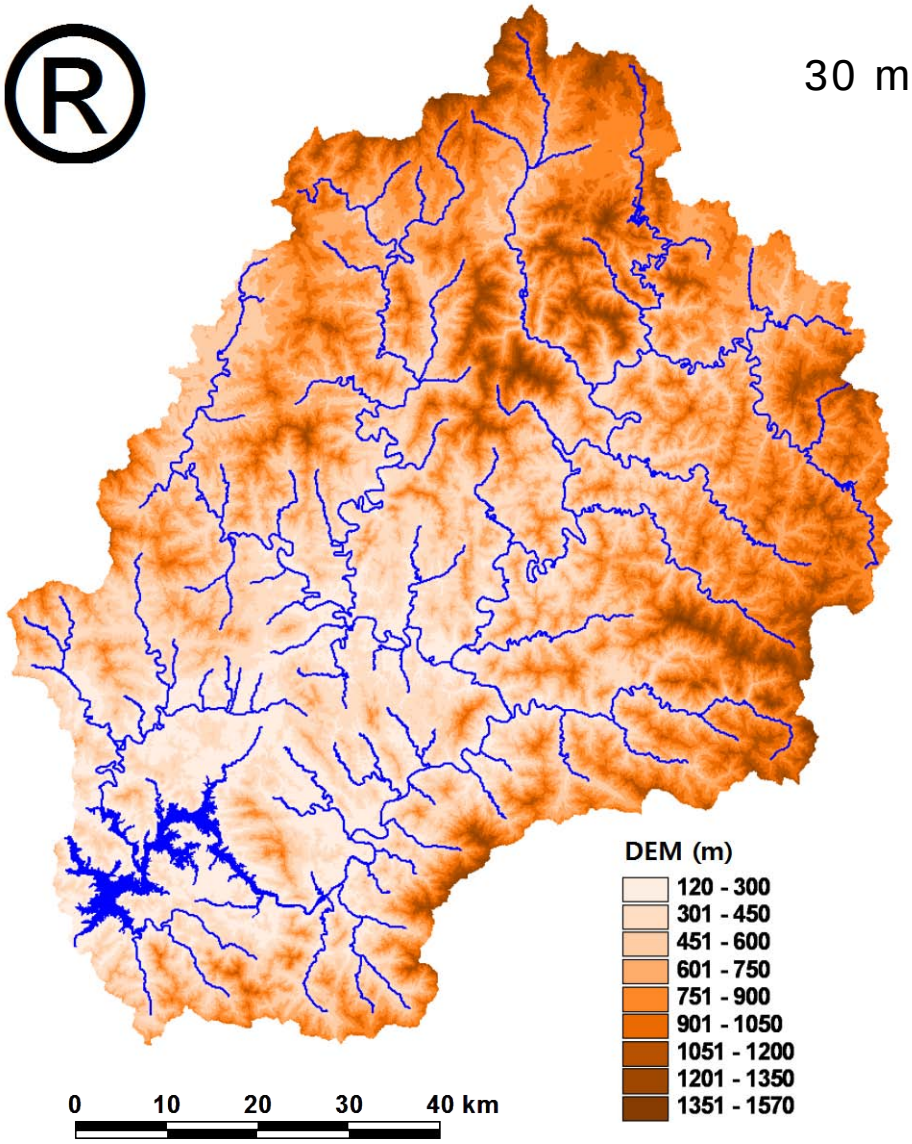
Five stations :

Daegwallyeong, Wonju, Yeongwol, Chungju, Jecheon

Daily data

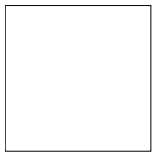
- **Rainfall**
- **Max. & Min. Temperature**
- **Wind Velocity**
- **Relative Humidity**
- **Solar Radiation**

Model input : DEM



30 m DEM from NGIS digital map (1/5,000)

Model input : soil



Detailed soil map (1/25,000) of NAAS (National Academy of Agricultural Science)

→ 128 soil groups

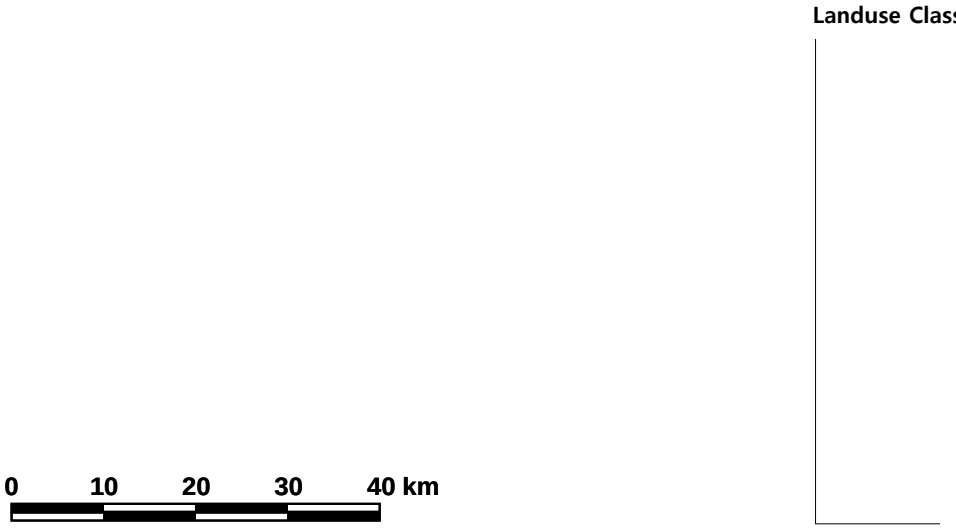
Soil Class

0 10 20 30 40 km

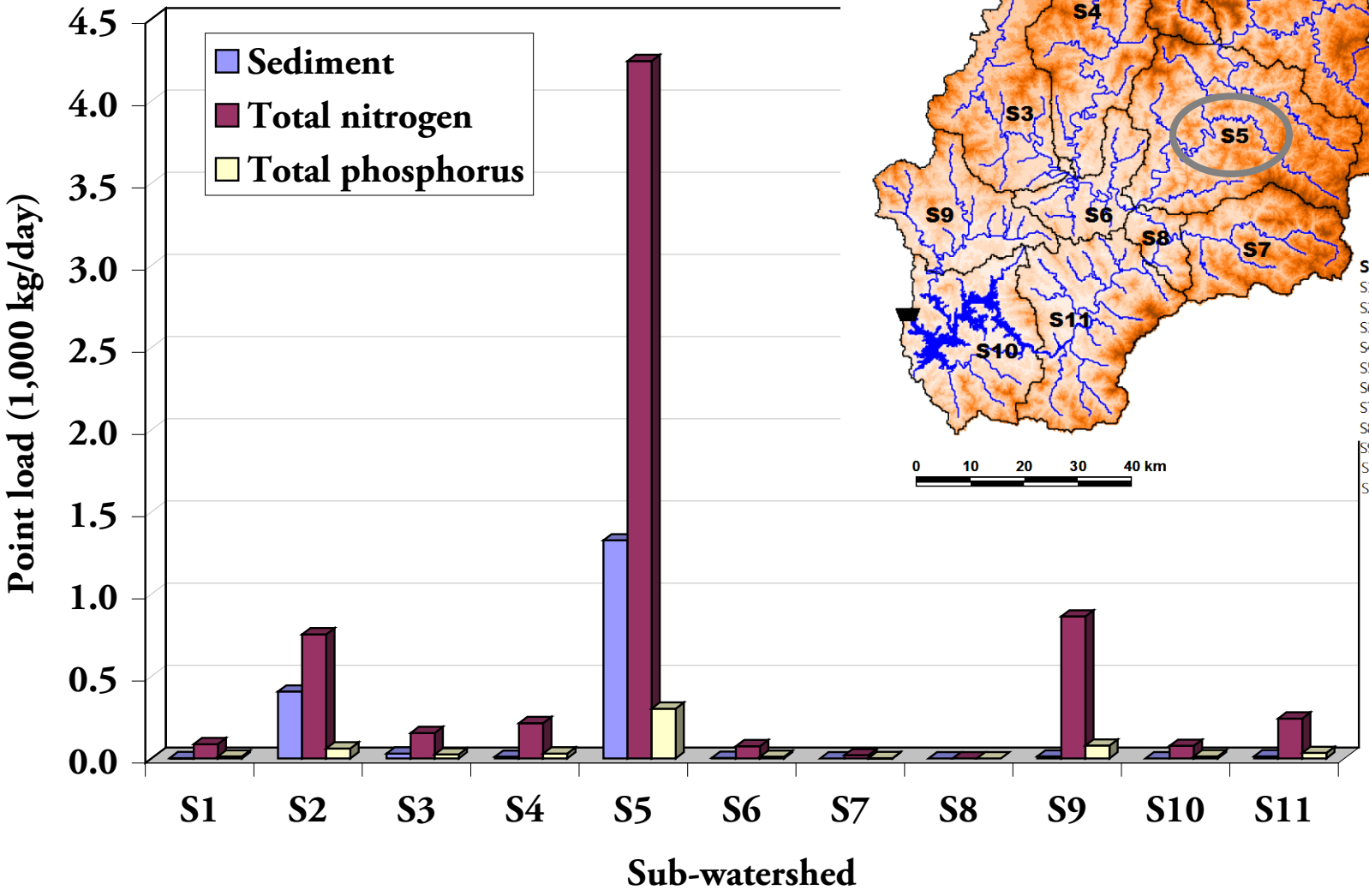
Model input : landuse

Level-2 landcover map of MOE
(Ministry of Environment)

→ Forest 83%, Upland 10%, Paddy 3%



Point source



Calibration & validation

Flow → **Sediment** → **Nutrients**

GW_DELAY
ALPHA_BF
GWQMN
SLSOIL
ESCO

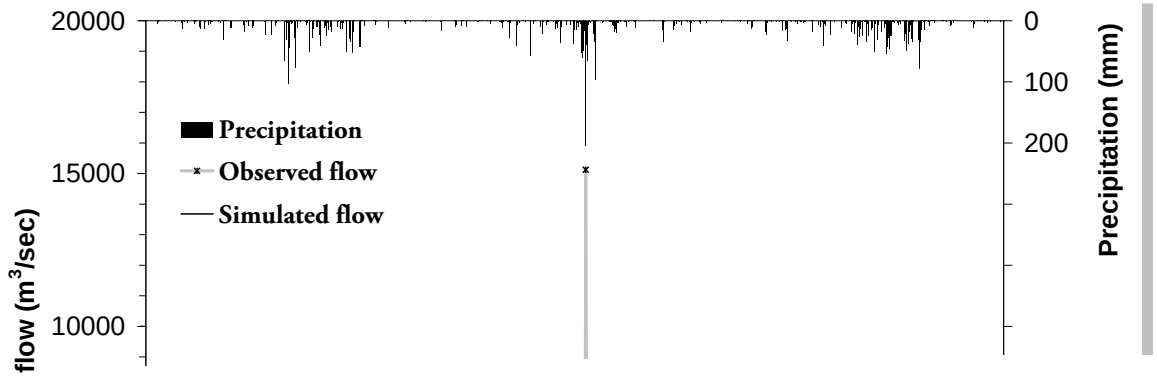
CH_EROD
CH_COV
ADJ_PKR
PRF
SPCON
SPEXP

SOL_NO3
FRT_LY1
RSDCO
NPERCO
AI1
SOL_ORGN
SOL_MINP
PPERCO
PHOSKD
AI2
SOL_ORGP

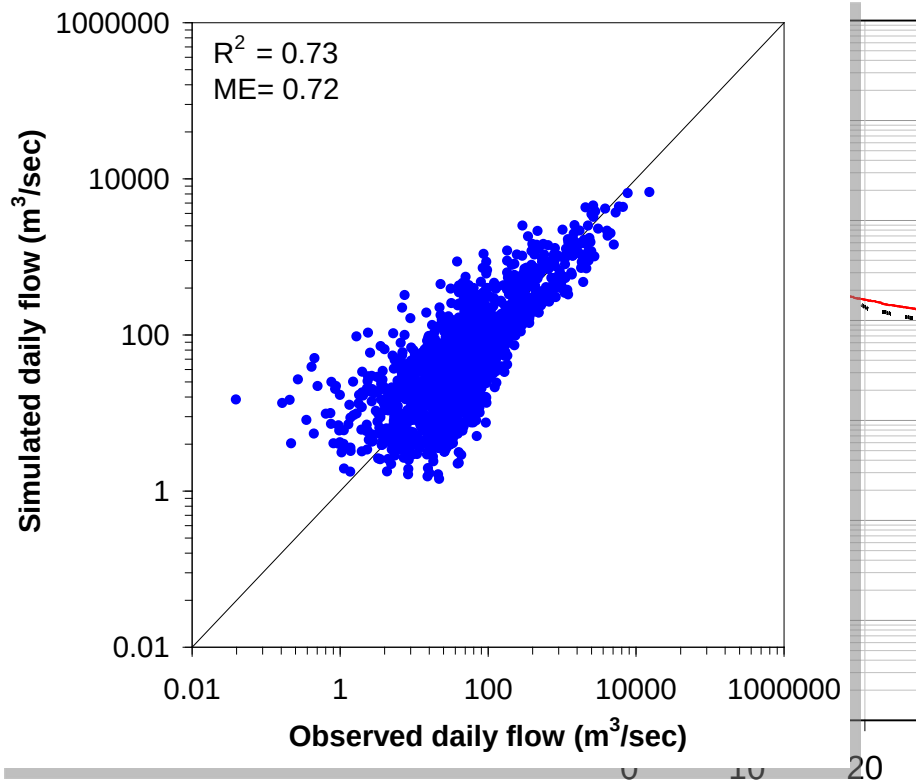
Statistical Criteria
coefficient of determination (R^2)
mean absolute error (MAE)
relative mean absolute error (RMAE)
Nash-Sutcliffe model efficiency (ME)

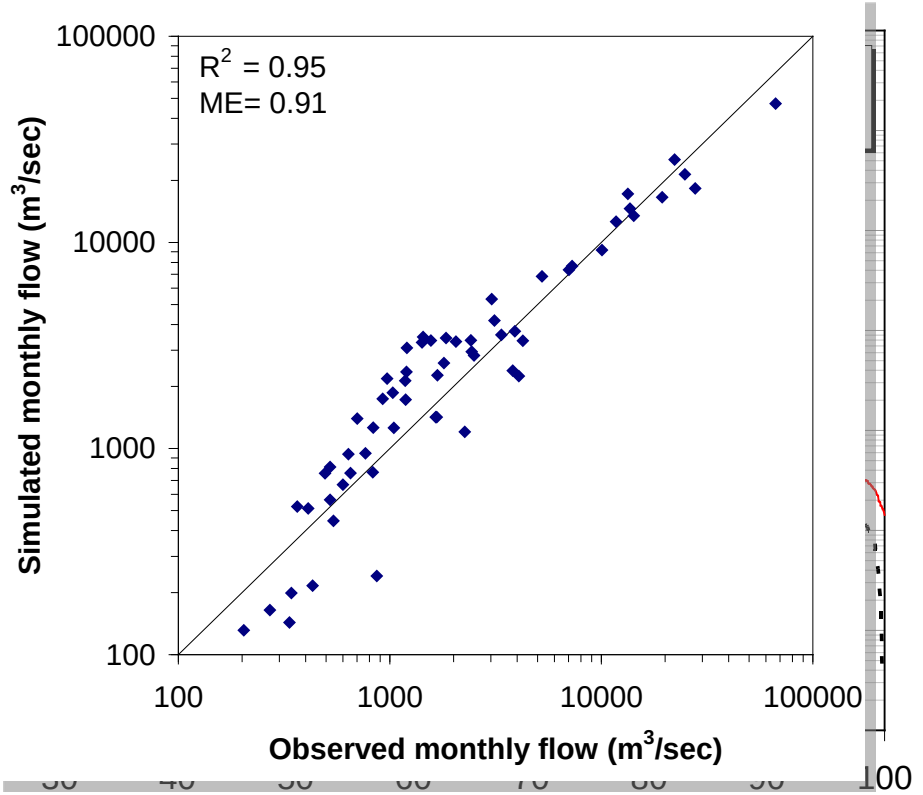
7-day window statistical criteria
% of observed values within 7-day MIN~MAX range
% of observed values > 7-day MAX
% of observed values < 7-day MIN
Average & Median

Calibration – flow



Inflow at the Chungju Dam for the period 2005~2009

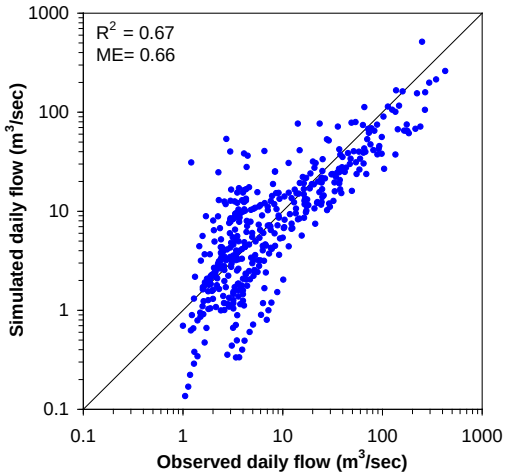


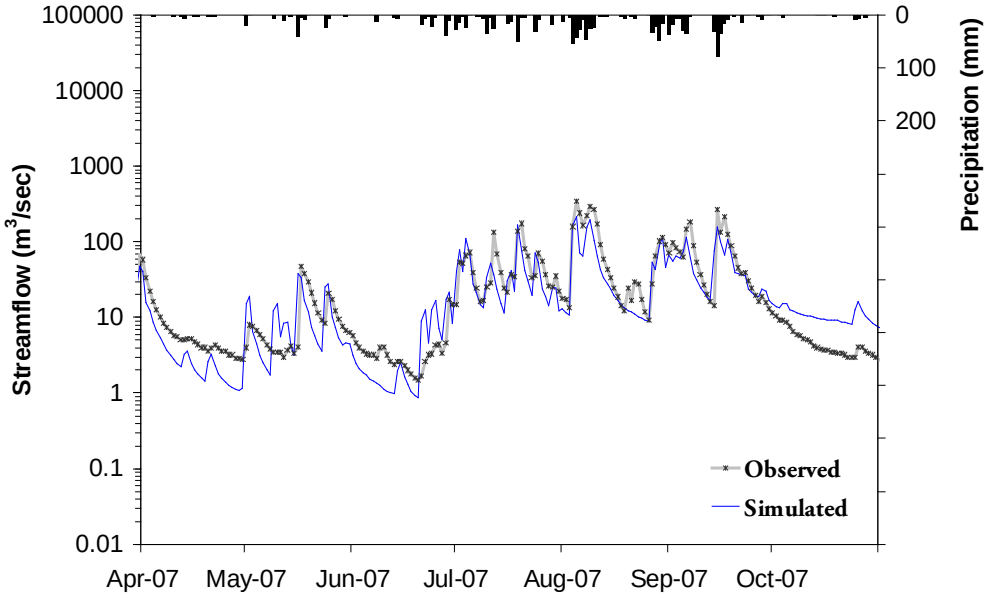


Exceedance frequency (%)

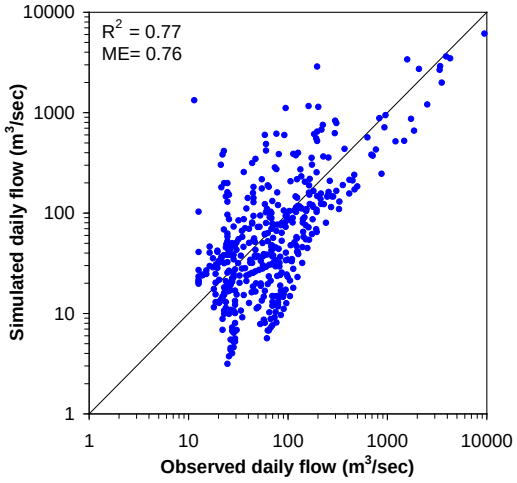
Validation – flow

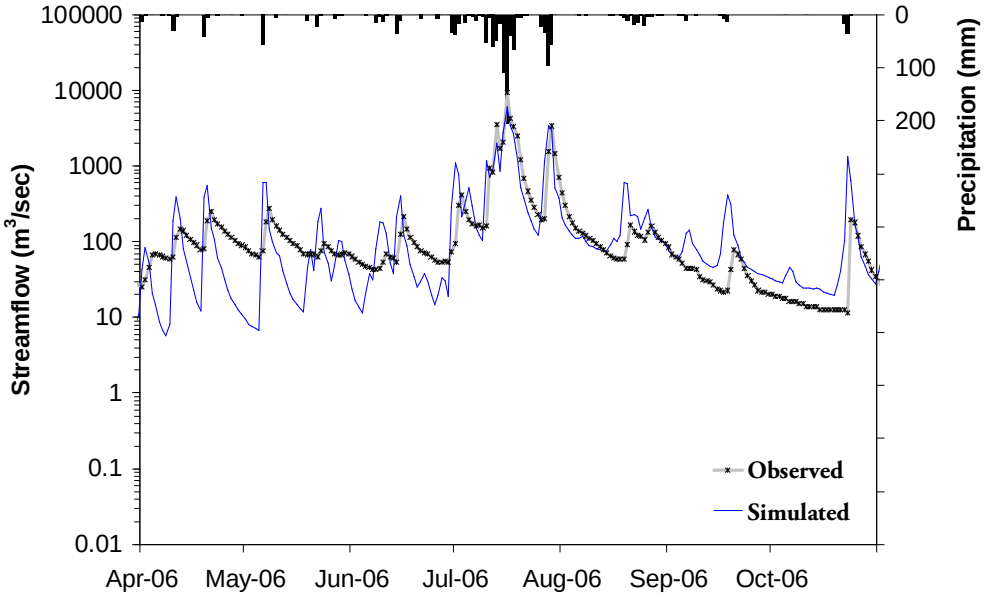
Jucheon station





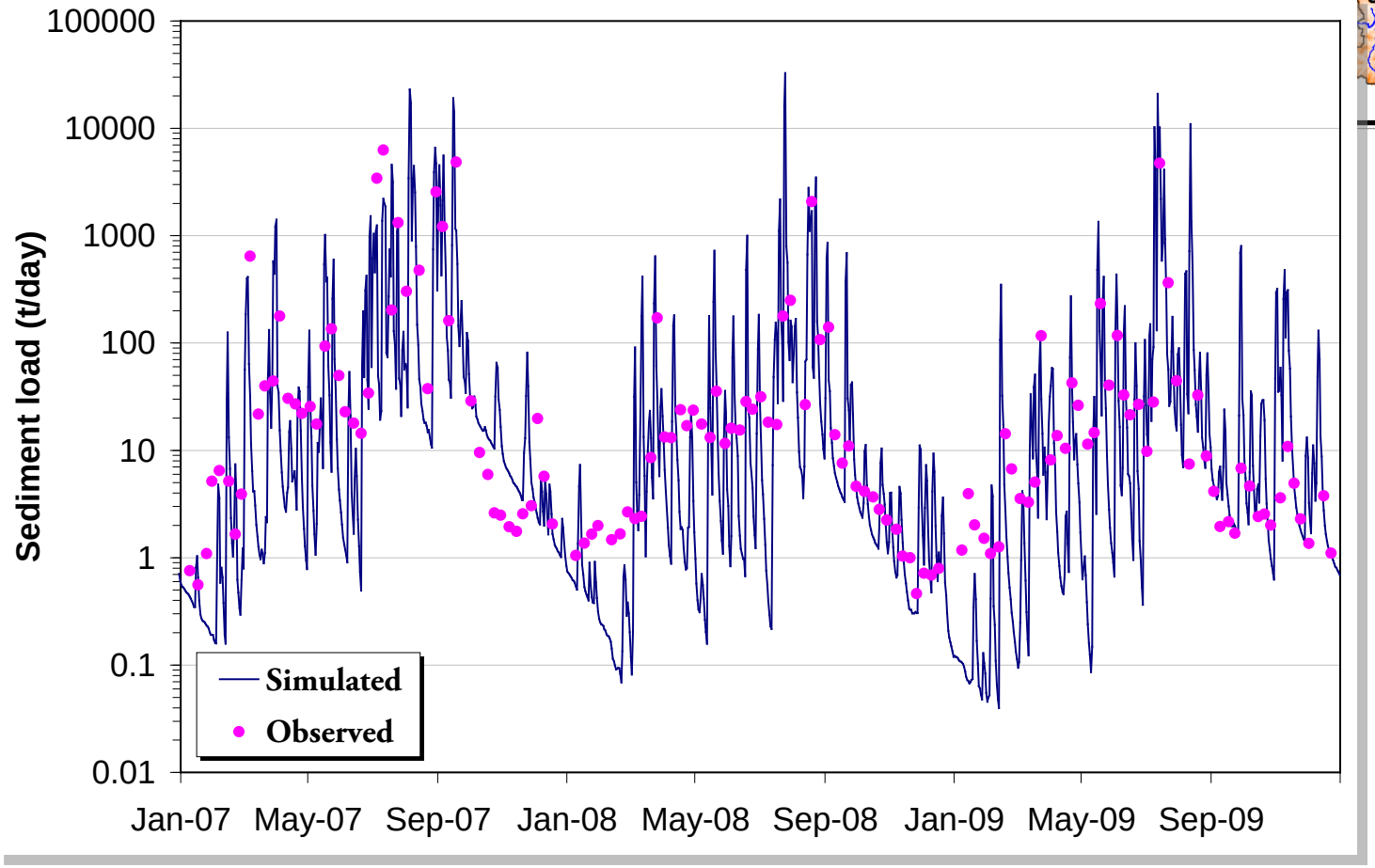
Yeongchun station

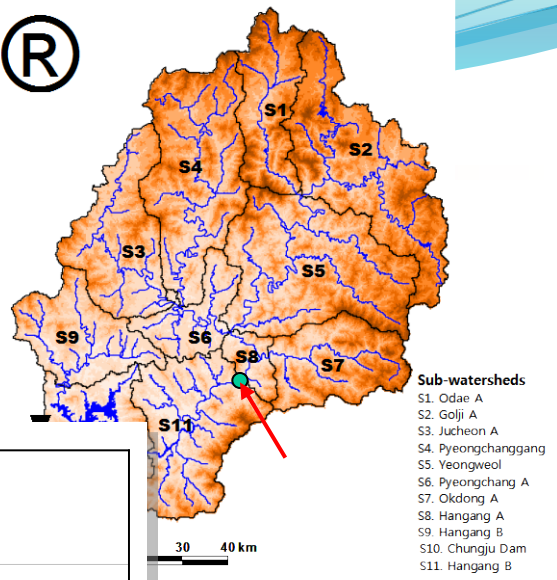




Calibration – sediment

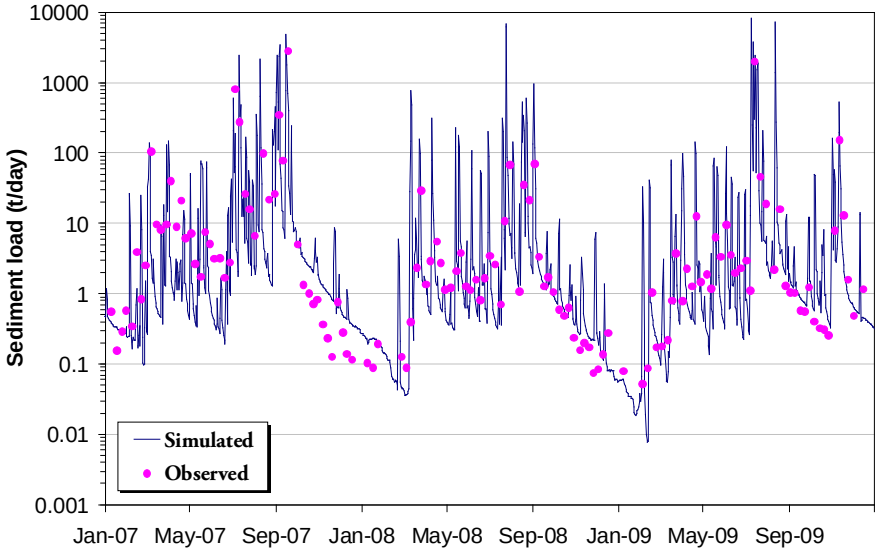
Observed and simulated daily sediment loads at the Hangang A

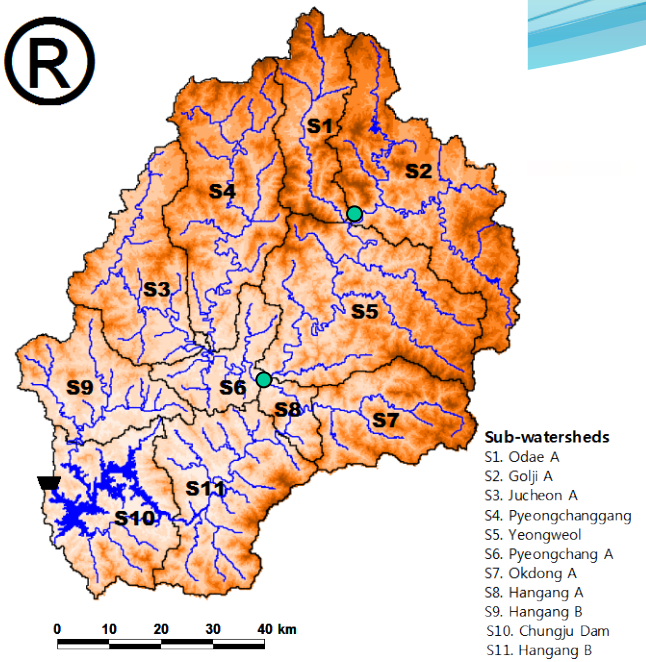




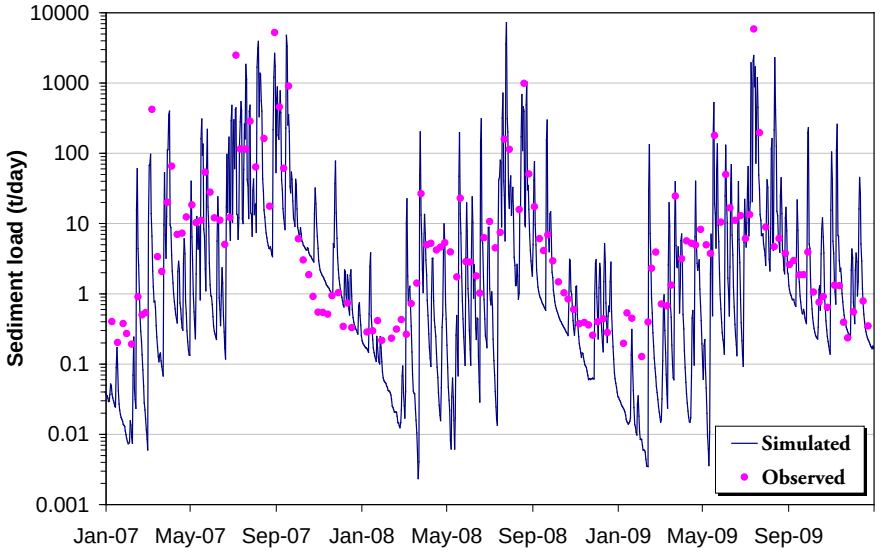
Validation – sediment

Golji A (S2)



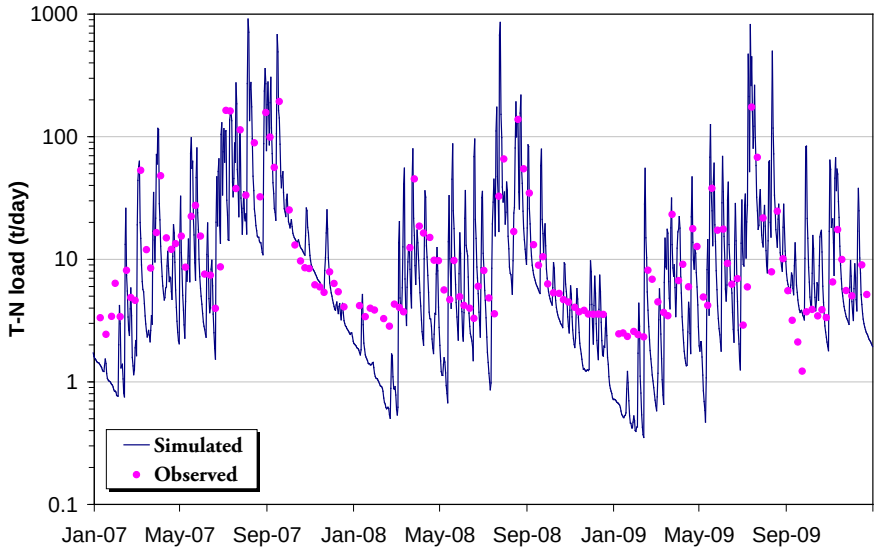


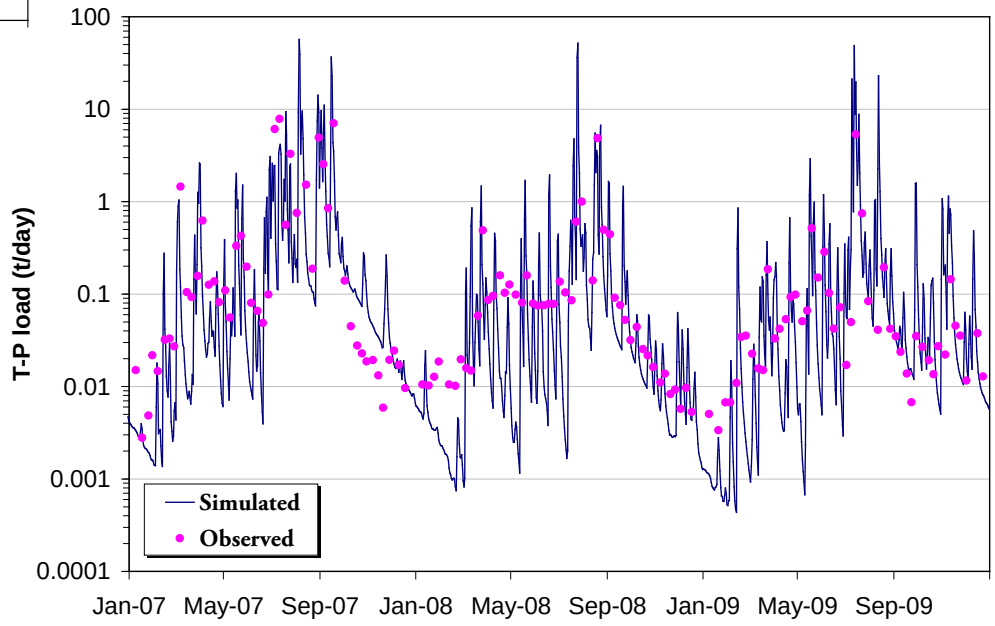
Pyeongchang A (S6)



Calibration – nutrients (N, P)

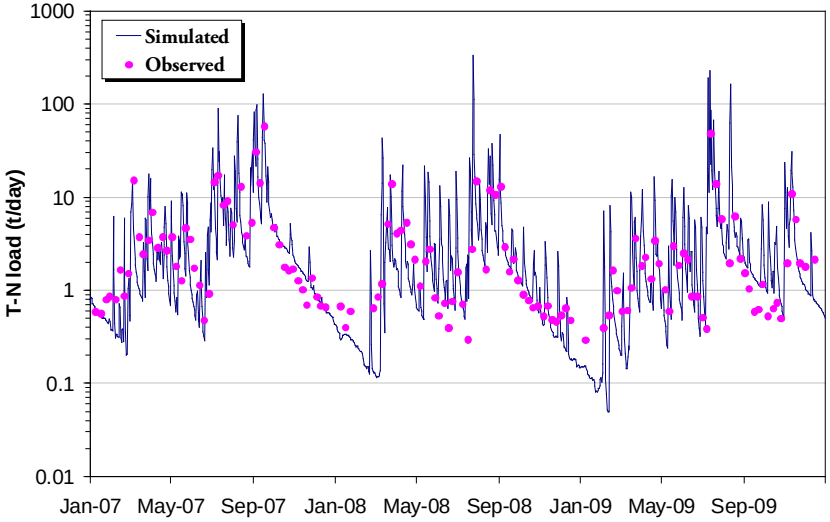
Observed and simulated daily nutrient loads at the Hangang A

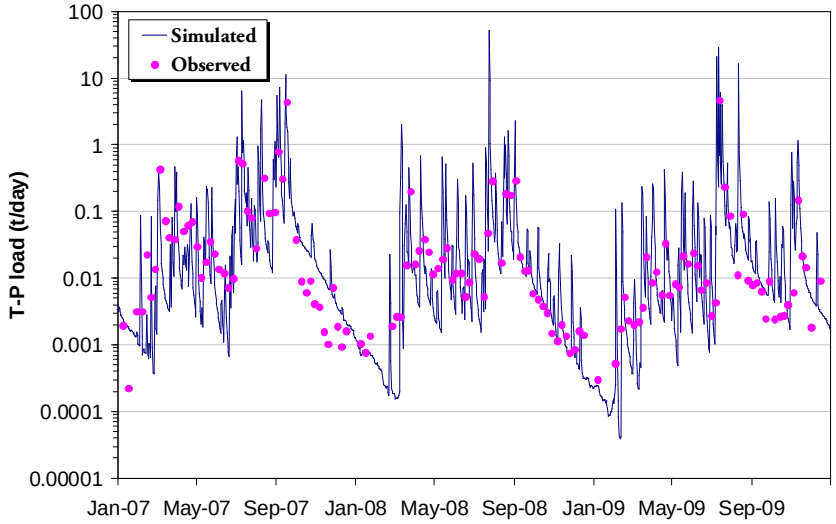




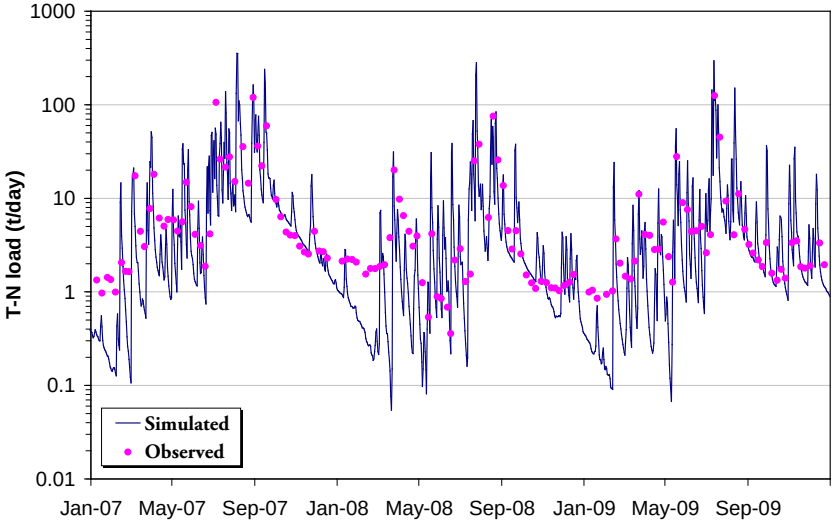
Validation – nutrients (N, P)

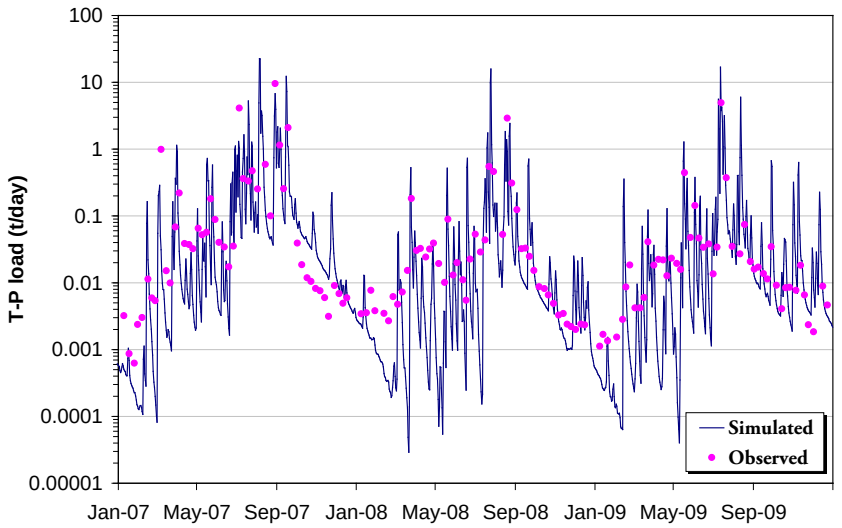
Golji A (S2)





Pyeongchang A (S6)



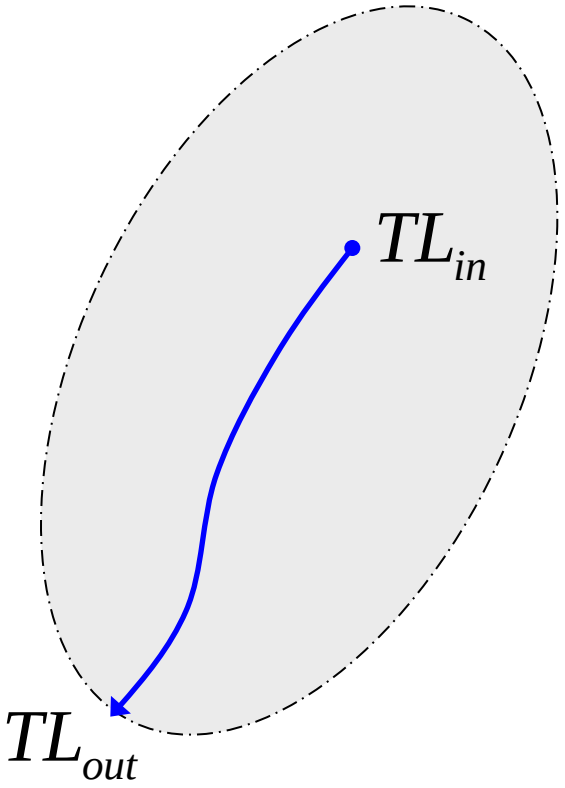


Calculation of transmission ratio

$$TR = \frac{TL_{out}}{TL_{in}}$$

Delivered load at the downstream point

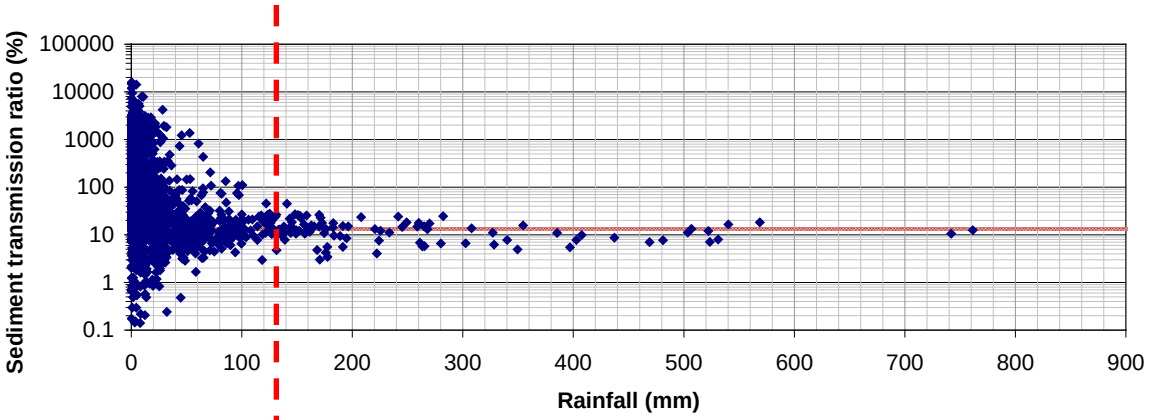
Point discharged load + Nonpoint discharged load
(+ Upstream load)



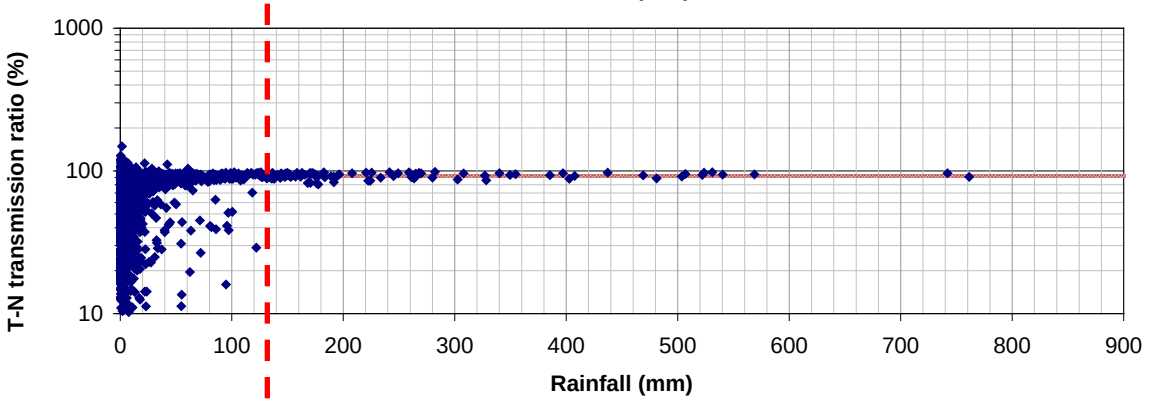
Estimating pollutant transmission ratios from the model results for the period 1980~2009 for various meteorological conditions

Transmission ratio by rainfall amounts

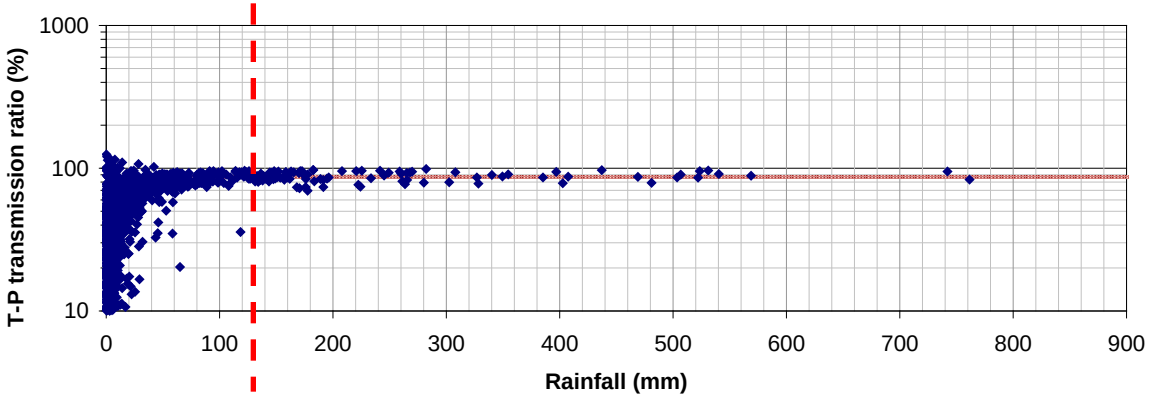
at the Golji A



13%

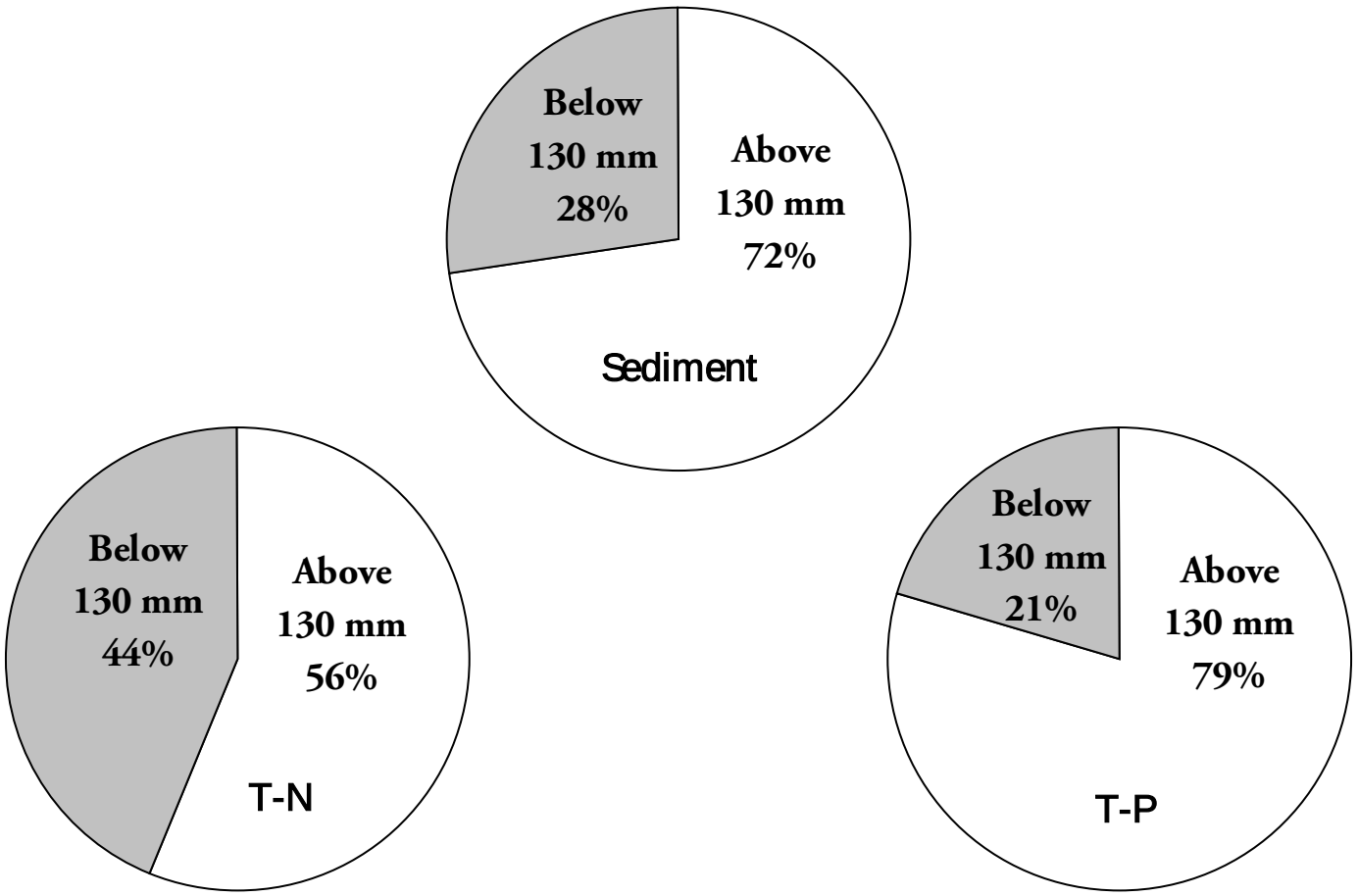


93%



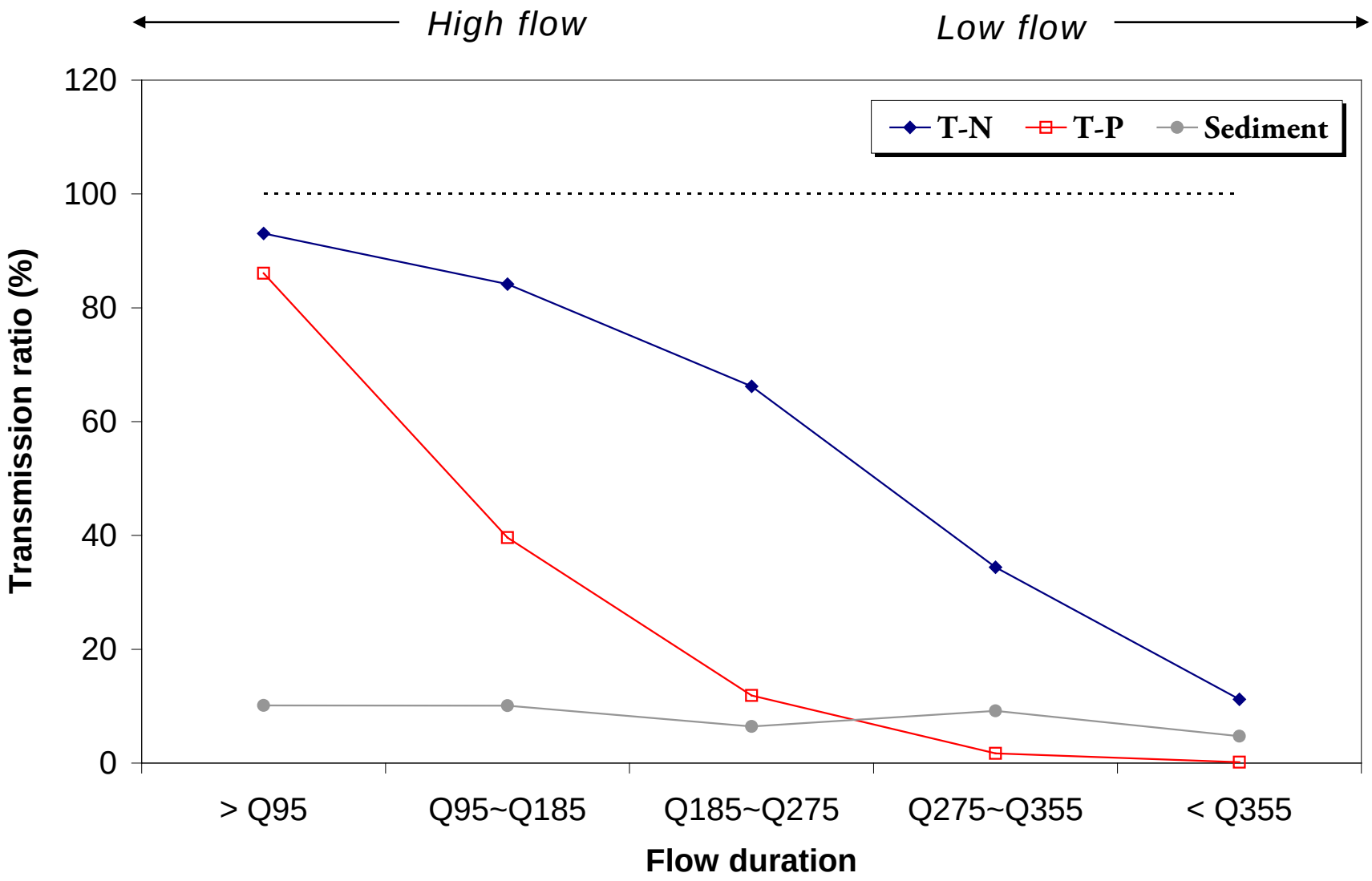
87%

Fraction of pollutant loads by rainfall amounts at the Golji A

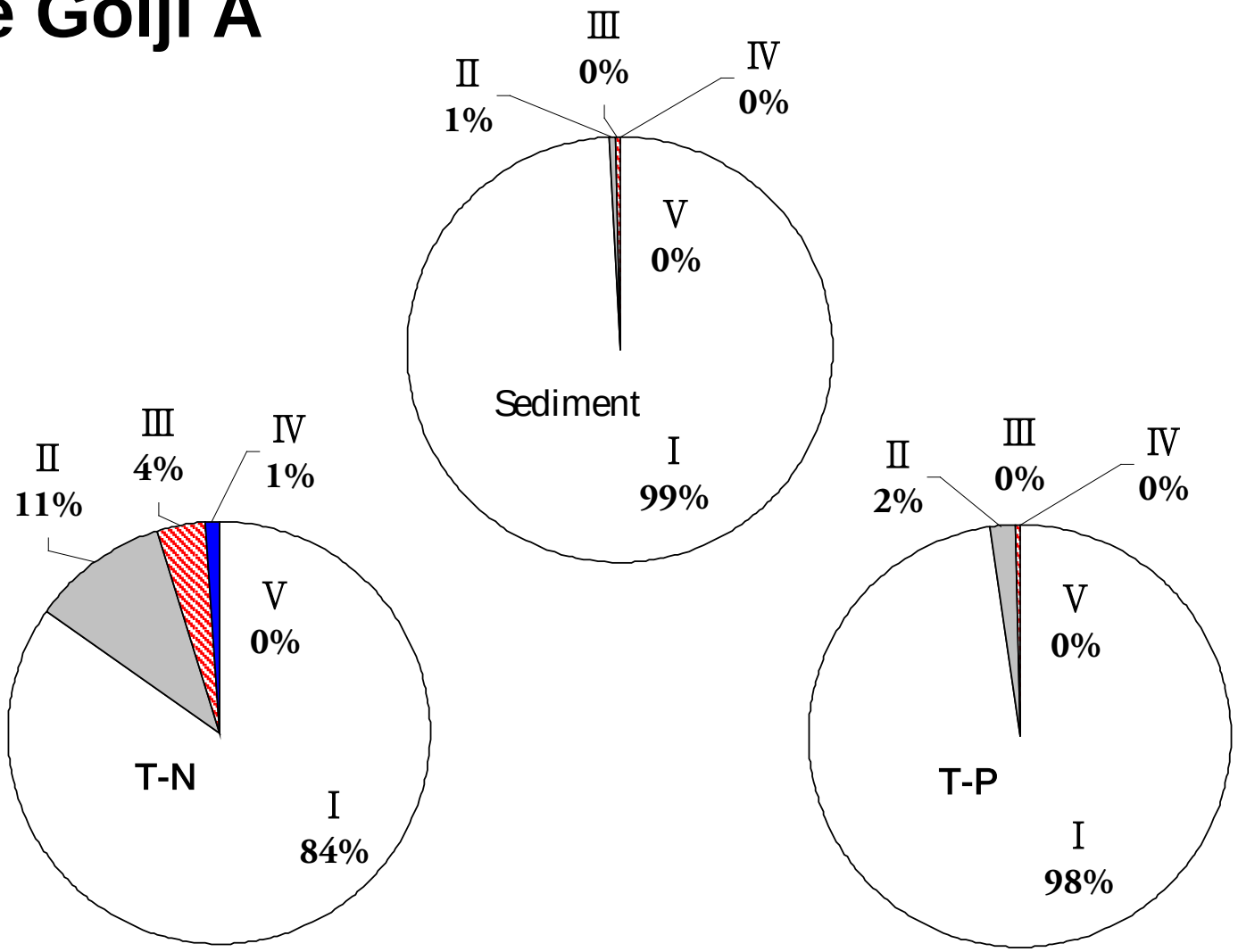


Transmission ratio for flow durations

at the Golji A

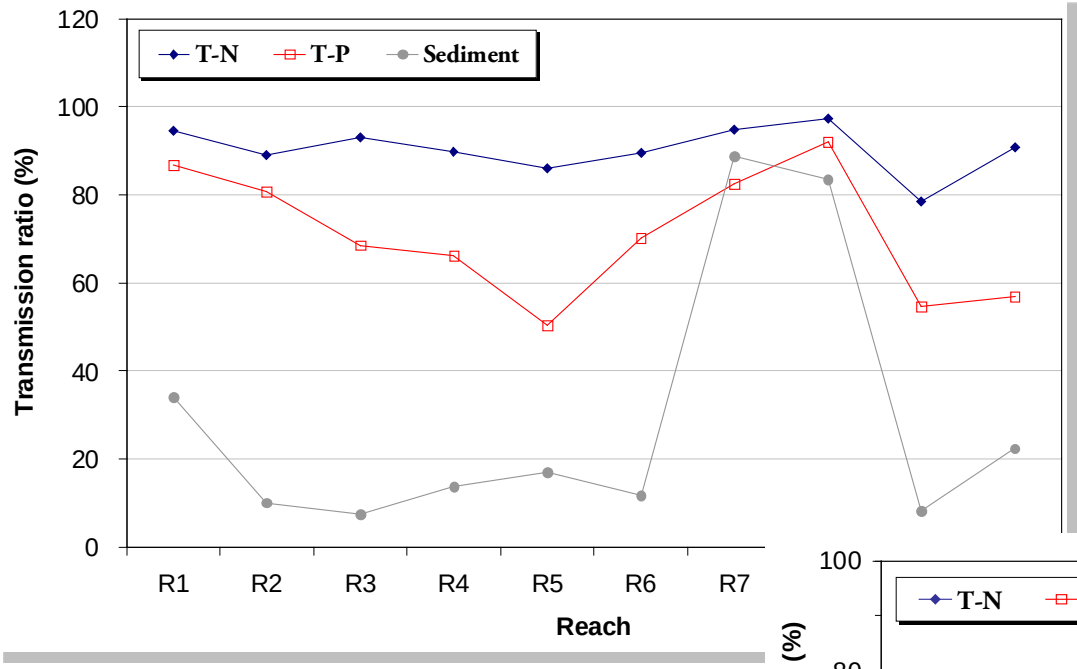


Fraction of pollutant loads for flow durations at the Golji A



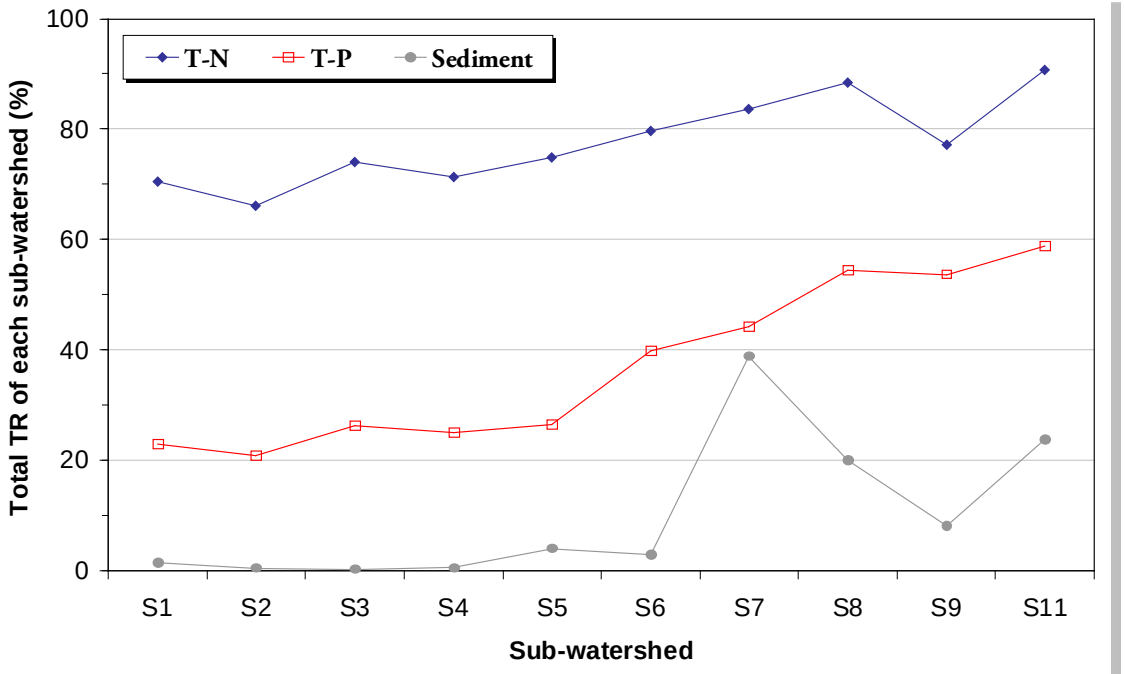
* Ⅰ : > Q95, Ⅱ : Q95~Q185, Ⅲ : Q185~Q275, Ⅳ : Q275~Q355, Ⅴ : < Q355

Total TR for sub-watersheds



Total TR from each sub-watershed to the Chungju Dam

$$TR_{total} = \prod_{i} TR_{(i)}$$

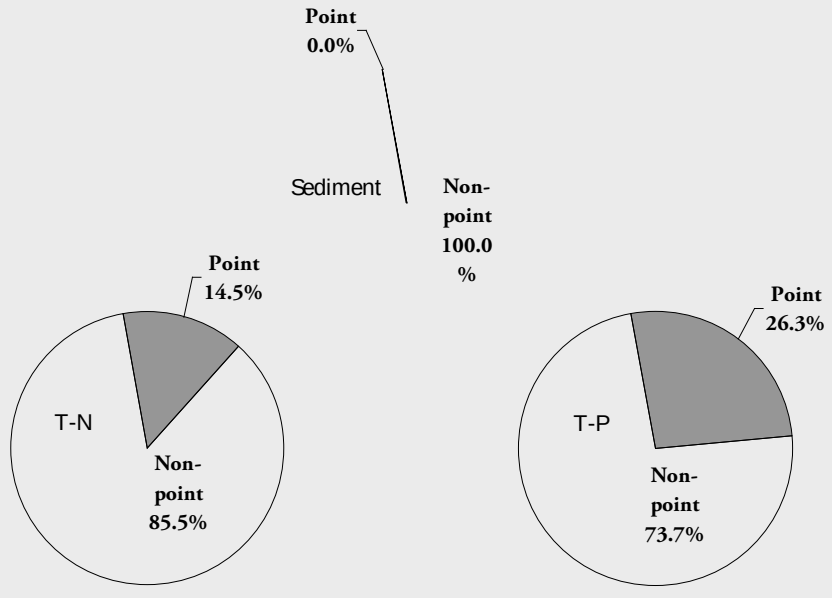


- Total TR of downstream sub-watersheds is higher than one of upstream areas

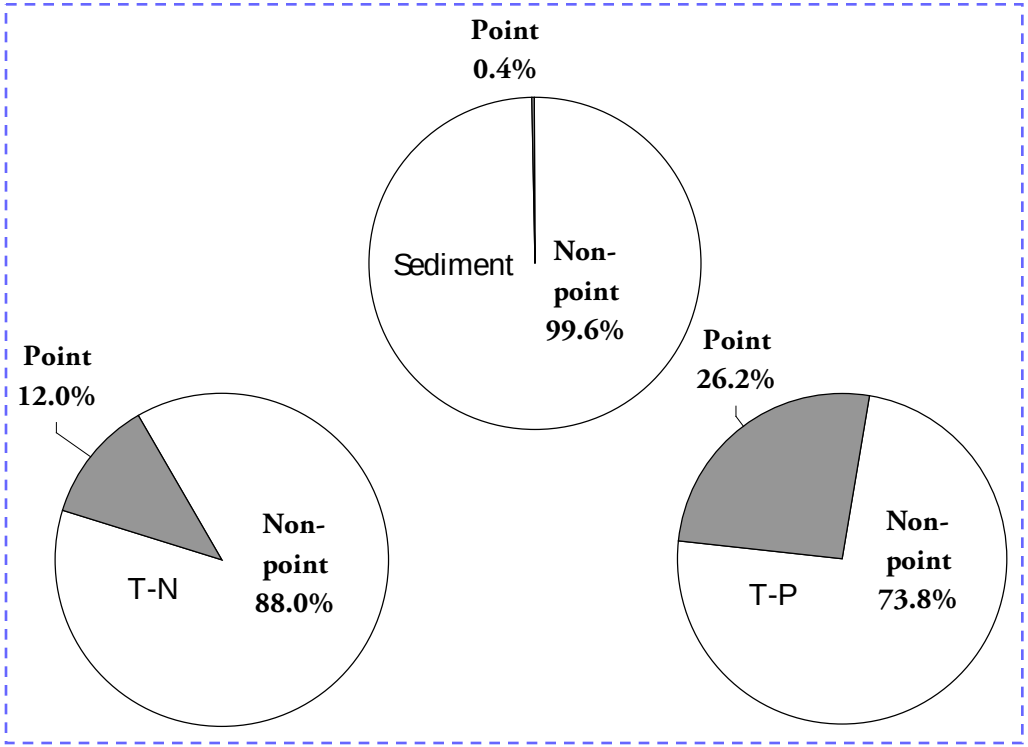
→ Application of BMPs to reduce pollutant export into the stream waterbodies near the mouth of the watershed would be more effective than application of the same ones on upstream areas near the head of the watershed

Contribution of point & nonpoint pollutants

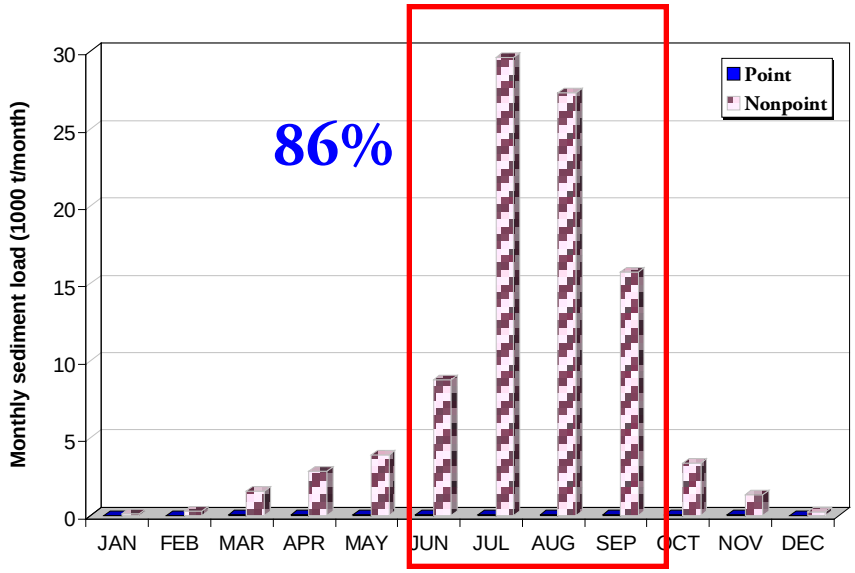
Fraction of point and nonpoint discharged loads in the watershed

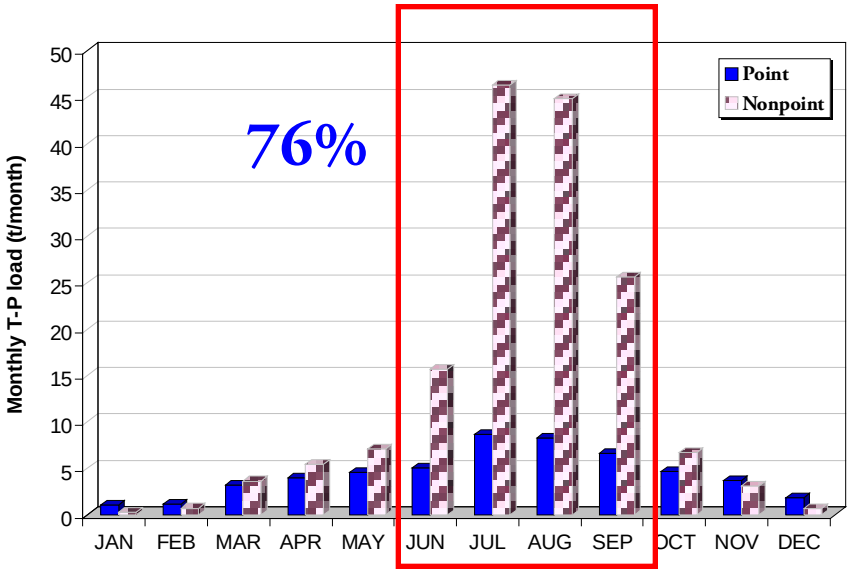


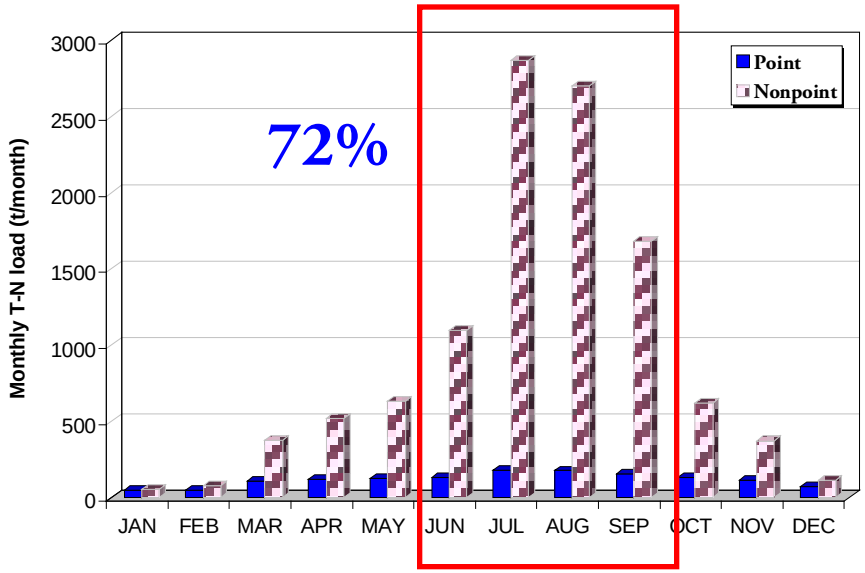
Fraction of point and nonpoint sources to the total loads delivered to the Chungju Dam



Monthly contribution







Conclusions

- ***Calculation of discharged and delivered loads for each sub-watershed using SWAT model***
- ***Analyzing the transmission characteristics of pollutants through streams***
- ***Assessing the impact of sediment & nutrients export to the Chungju Dam***


Q & A
Thank You !