Evaluation of SWAT Model Reliability for Long-Term Runoff Simulation: A Case Study of the Seolma-cheon Watershed

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Contents

1. Introduction

- **Goal**

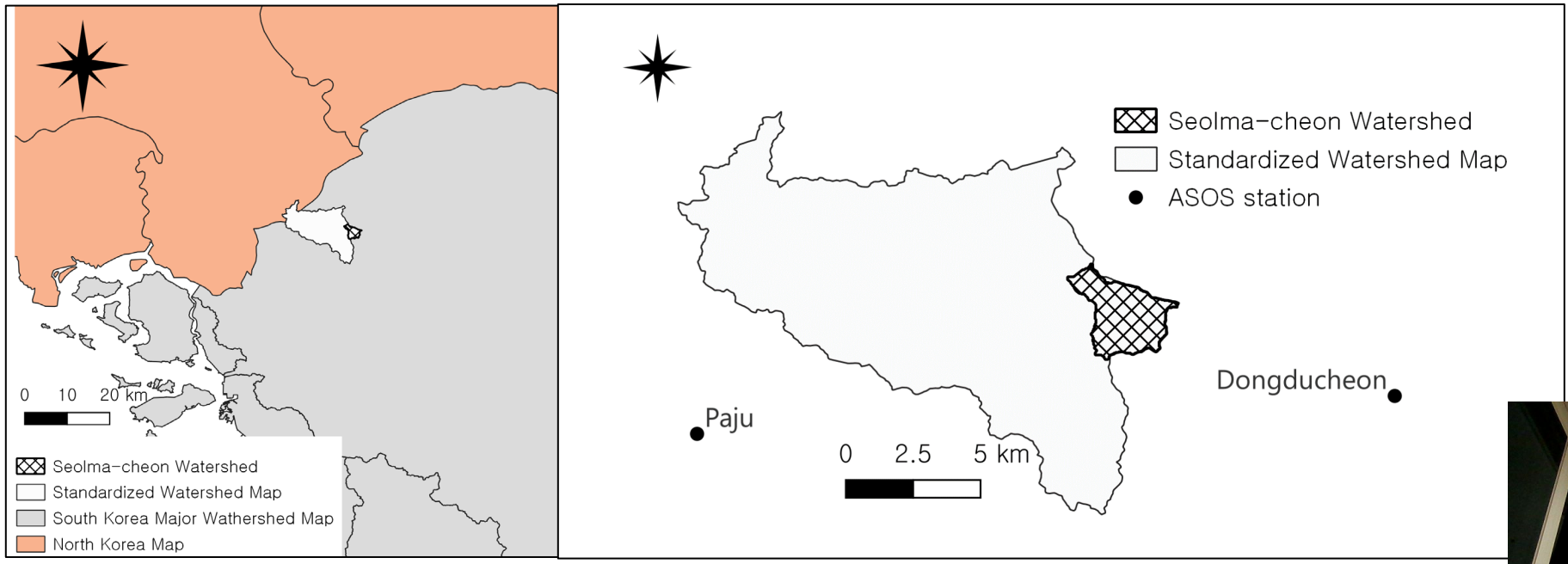
  - Analysis of annual hydrologic component variations based on long-term monitoring data
  - To evaluate the reliability of long-term runoff simulation using the SWAT model in Seolma-cheon watershed with an extensive record of observed hydrological data.

1. Introduction

▪ Study Site

✓ Seolma-cheon watershed

- Location : In Jeokseong-myeon, Paju-si(city), Gyeonggi Province, South Korea
- Basin area : 9.03 km²
- Stream length : 5.59 km.



[Sources : (Watershed map) https://www.vworld.kr, (North Korea map) https://simplemaps.com]

2. Data and Methodology

- **Review of existing research on the Seolma-cheon Stream**

Kim, N., Lee, J., Chung, I.-M., & Kim, D. (2008). **Hydrologic component analysis of the Seolma Stream watershed using the SWAT-K model**. *Journal of Environmental Science International 17 (12), 1363-1372*

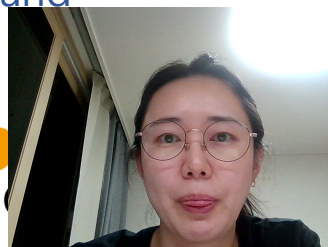
"The SWAT-K model simulated hydrologic components from 2004 to 2006, showing good agreement with observed evapotranspiration and runoff data."

Kim, D. P. (2011). **Water Balance Analysis using Observation Data of the Seolma-Cheon Experimental Catchment of the 2010**. *In Proceedings of the Korea Water Resources Association Conference* (pp. 311-315). Korea Water Resources Association.

"This study analyzed the water cycle in the Seolma-cheon watershed, a representative mountainous small watershed, using observational data from the year 2010."

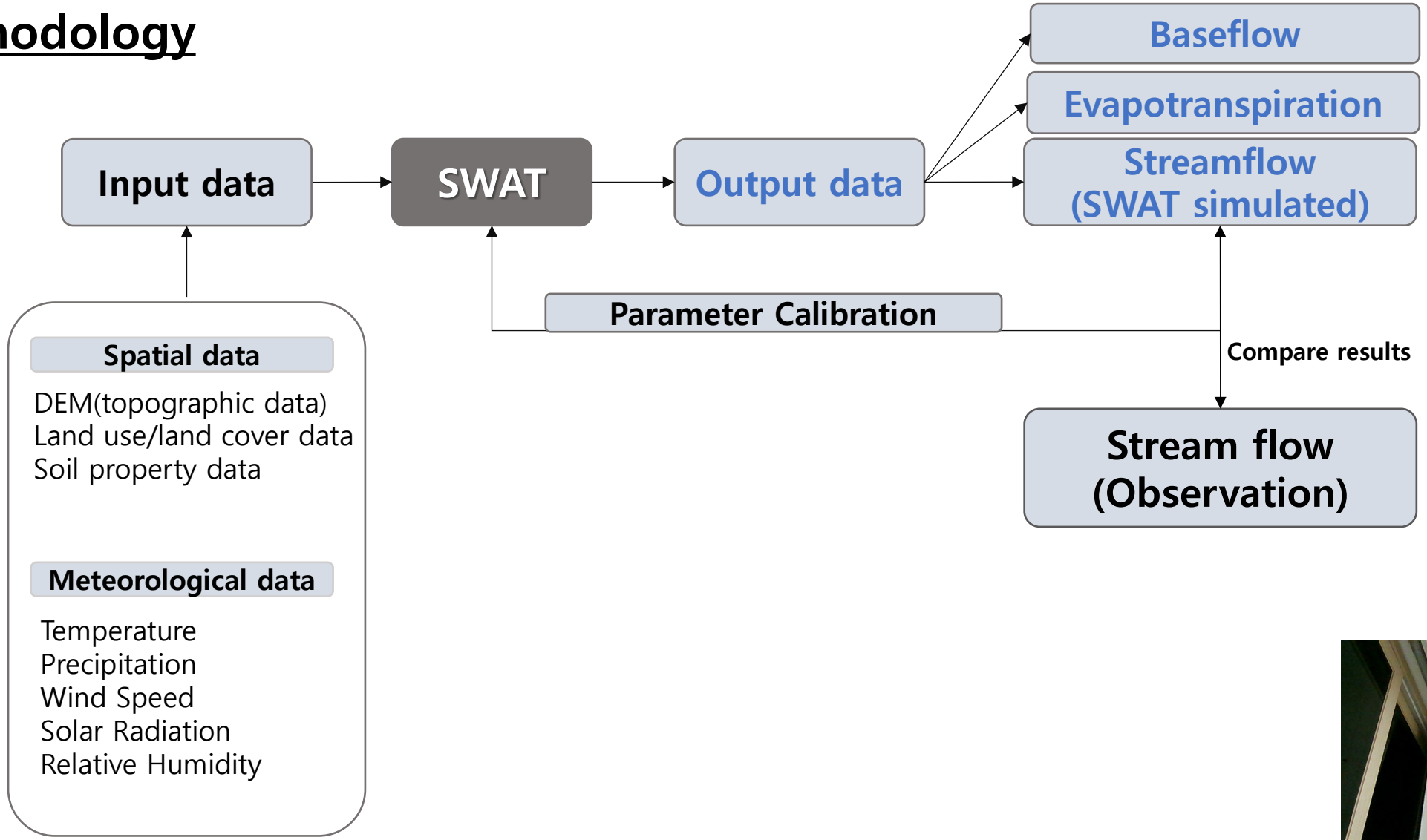
Ahn, S., Park, G., Jang, C., & Kim, S. (2013). **Assessment of Climate Change Impact on Evapotranspiration and Soil Moisture in a Mixed Forest Catchment Using Spatially Calibrated SWAT Model**. *Journal of the Korea Water Resources*, 46(6), 569–583.

"The SWAT model was calibrated and validated using observed data in the Seolma Stream watershed, and hydrological responses were analyzed under current and future (RCP 4.5 & 8.5) climate scenarios."



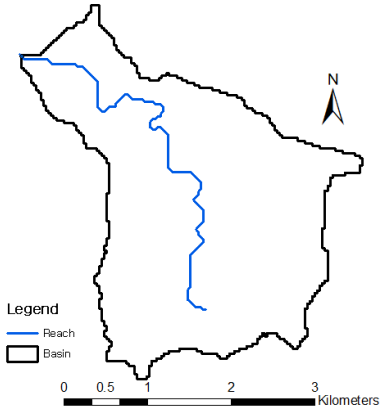
2. Data and Methodology

- **Methodology**

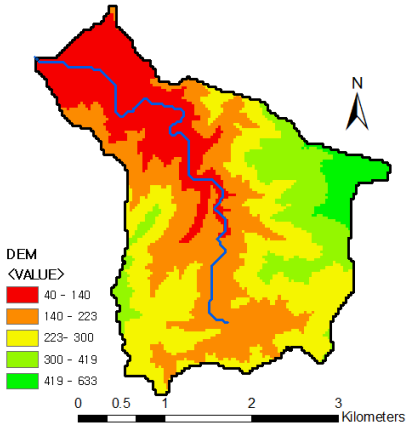


2. Data and Methodology

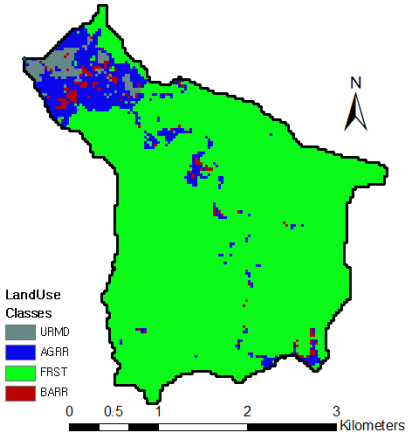
- **SWAT simulation**
  - ✓ Spatial data



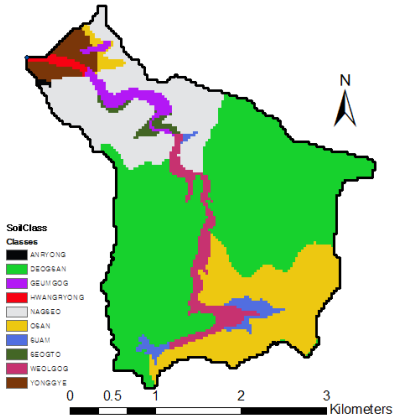
[Basin]



[DEM]



[Land use]



[Soil Data]

Land use	%
URMD	2.382
AGRR	8.819
FRST	**87.394**
BARR	1.405

Soil Data	%
ANRYONG	0.12
DEOGSAN	**52.207**
GEUMGOG	2.392
HWANGRYONG	0.727
NAGSEO	**16.861**
OSAN	**17.349**
SUAM	
SEOGTO	
WEOLGOG	
YONGGYE	

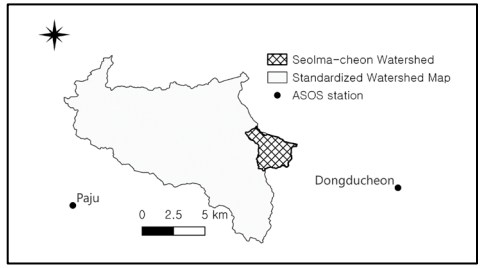
2. Data and Methodology

▪ SWAT simulation

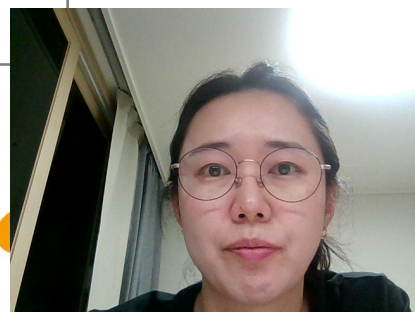
✓ Meteorological Data: Temperature, Precipitation, Wind, Humidity, and Sunshine Duration

- Data Source: ASOS* stations from KMA (period: 2004.01–2023.12)

  * Automated Surface Observing System (ASOS)

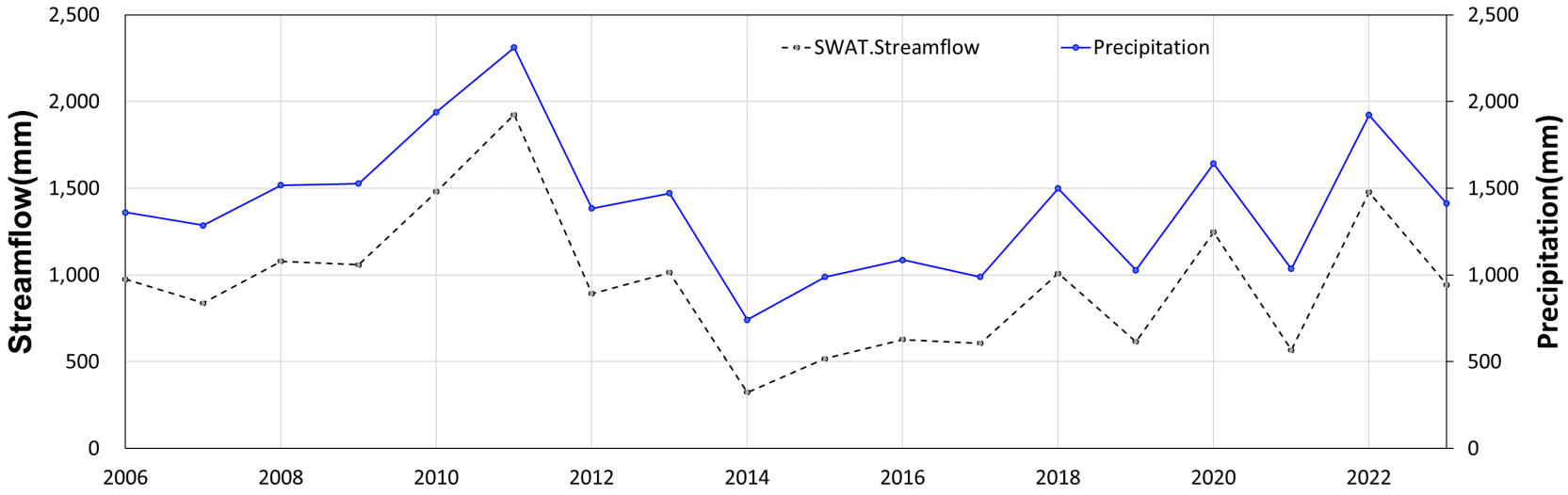


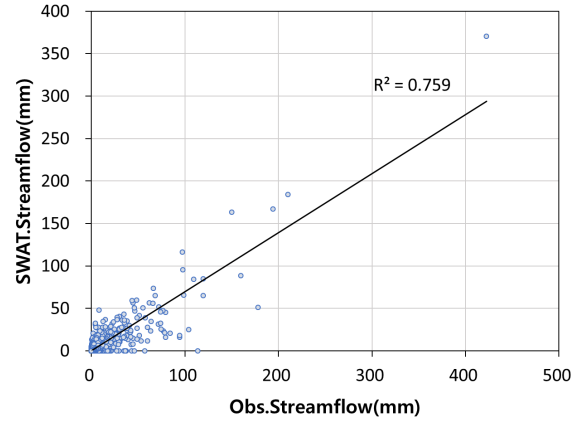
Meteorological Data	2004~2014	2015~2024	Gap
Maximum Temperature(°C)	33.0~36.4 (34.8)	34.3~38.7 (35.9)	+1.1
Minimum Temperature(°C)	-20.7~-13.8 (-17.8)	-20.4~-13.4 (-17.5)	+0.3
Annual Precipitation(mm)	742~2,311 (1,571)	988~1,922 (1,289)	-282
Wind Speed(m/s)	1.4~1.8 (1.6)	1.1~1.7 (1.4)	-0.2
Average Relative Humidity(%)	64~68 (66)	61~73 (67)	+1.0
Sunshine Duration(hr)	5.1~6.6 (5.8)	6.3~7.1 (6.7)	+0.9



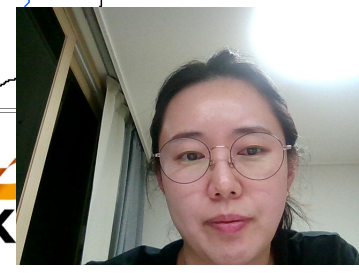
3. Results

- **SWAT simulation(Streamflow)**
  - ✓ Warming-up: 2004~2005(2yrs), Calibration: 2006~2014(9yrs), Validation: 2015~2021(7yrs)
  - ✓ Observed Streamflow data : Jeonjeokbi station (period: 2004.01–2023.12)

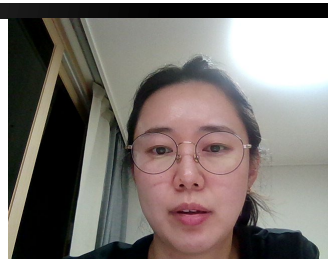




Runoff rate(%)	Calibration(2006~2014)	Validation(2015~2021)
SWAT	43~83(68)	52~76(61)
Observed Streamflow	26~77(60)	29~64(53)

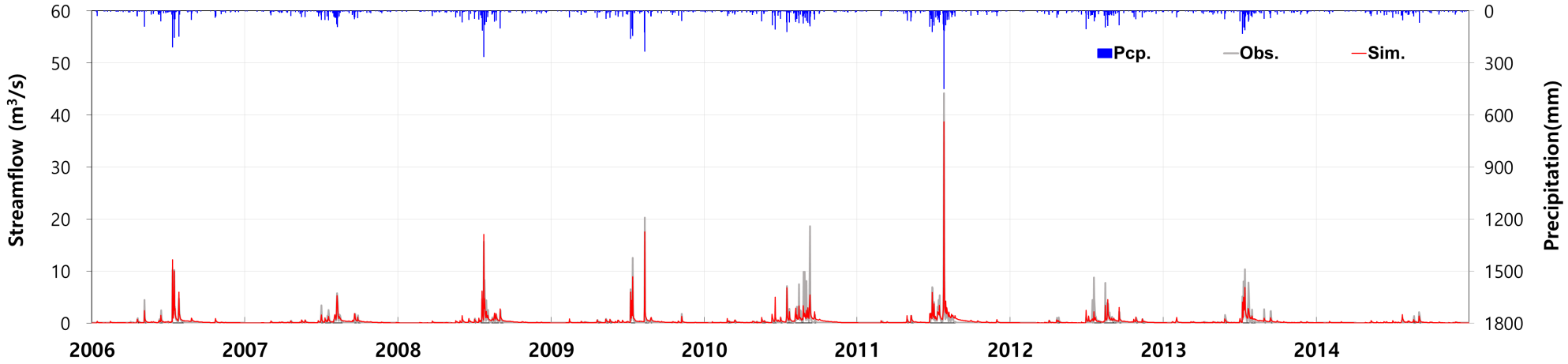


3. Results



- **SWAT simulation(Streamflow)**

  ✓ Calibration(2006~2014)

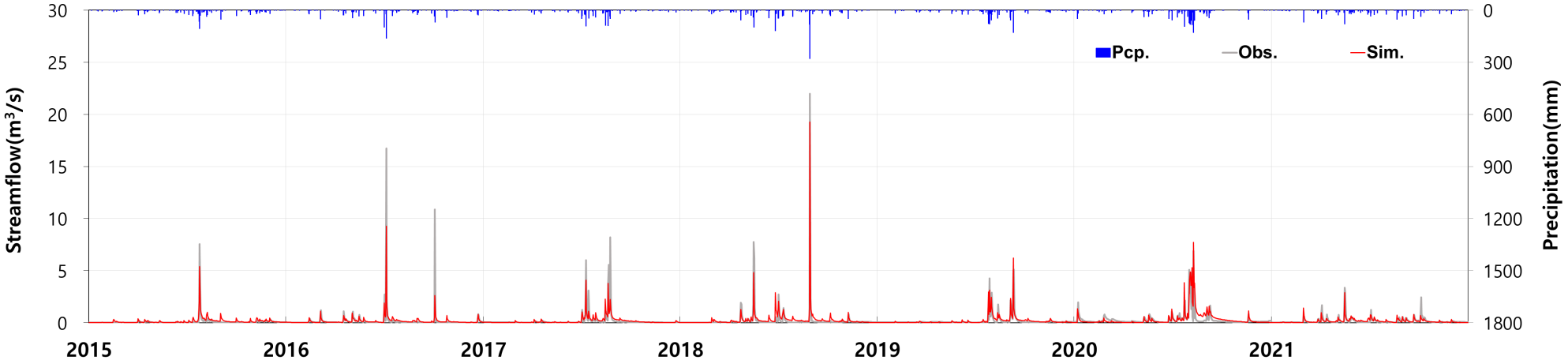


Statistics	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
RMSE	4.06	2.38	3.44	3.33	10.45	6.00	5.47	5.24	1.21	**4.62**
NSE	0.81	0.78	0.88	0.93	0.44	0.94	0.52	0.72	0.49	**0.73**
RBIAS	-15.31	-30.74	-21.43	-21.43	0.57	-17.83	6.36	2.14	-64.37	**-18.55**
R^2	0.82	0.89	0.89	0.96	0.49	0.96	0.56	0.81	0.55	**0.76**

3. Results

- **SWAT simulation(Streamflow)**

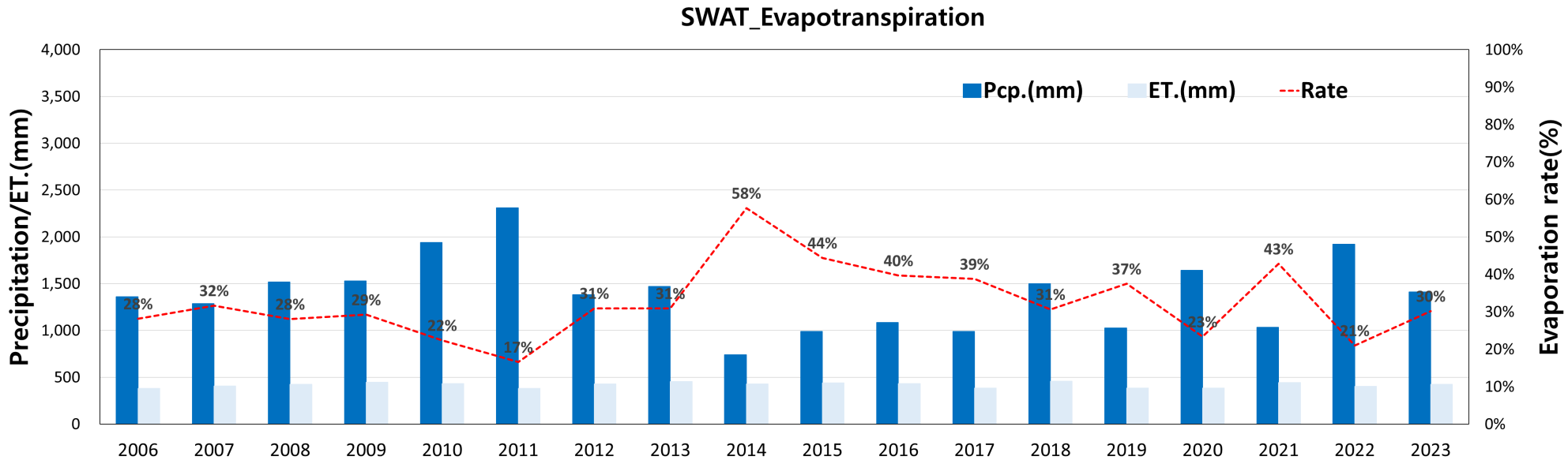
  ✓ Validation(2015~2021)



Statistics	2015	2016	2017	2018	2019	2020	2021	Average
RMSE	1.77	5.80	4.28	4.07	2.67	3.77	2.08	**3.46**
NSE	0.82	0.67	0.58	0.89	0.70	0.63	0.54	**0.67**
RBIAS	-81.61	-1.21	0.58	-31.86	-8.64	-18.51	2.62	**-24.21**
R^2	0.86	0.85	0.64	0.91	0.71	0.74	0.54	**0.74**

3. Results

- **SWAT simulation(Evapotranspiration, ET.)**



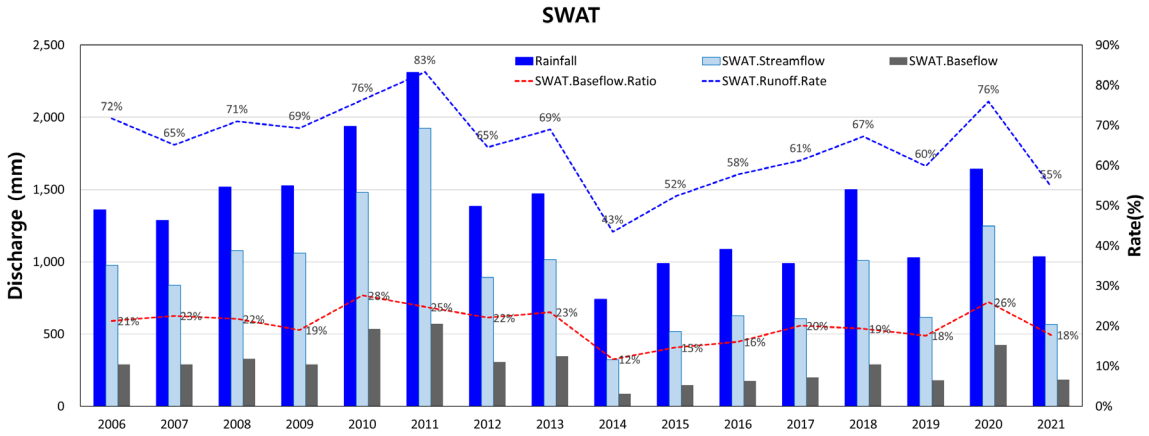
ET.Ratio(%)	2006~2014	2015~2021	Previously reported values
SWAT	17%~58%(avg. 31%)	21%~44%(avg. 37%)	Kim(2008) : 28.3~30.5% Ahn(2013) : 25.0~32.0%

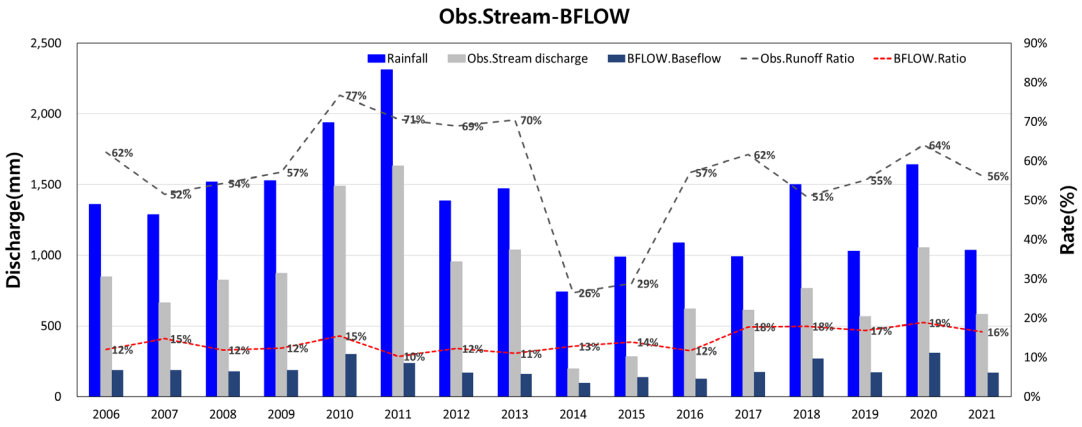
3. Results

▪ SWAT simulation(Baseflow)

✓ BFLOW is a baseflow separation program developed by the United States Geological Survey (USGS). It is an automated tool designed to extract the baseflow component from daily streamflow records.

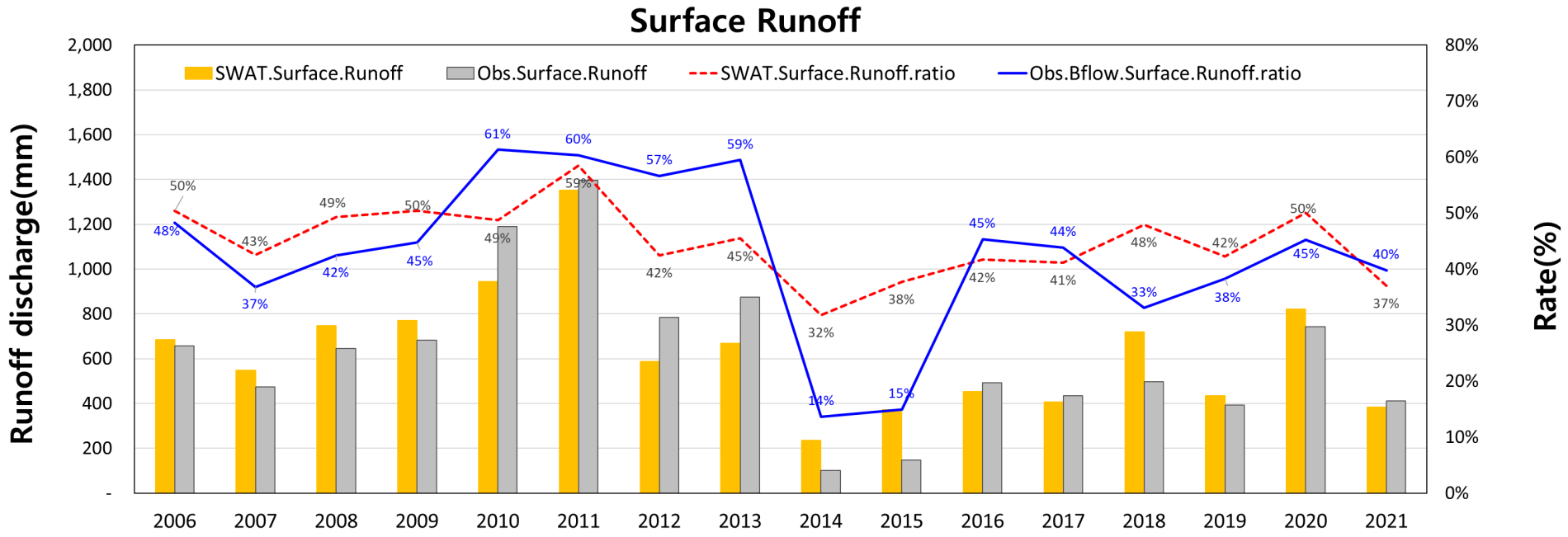
Baseflow Ratio(%)	2006~2014	2015~2021	Previously reported values
SWAT	12%~28%(avg. 22%)	15%~26% (avg. 19%)	Kim(2008) : 17.5~19.6%
BFLOW	10%~15%(avg. 13%)	12%~19% (avg. 16%)	





3. Results

- **SWAT simulation(Surface Runoff)** * Surface Runoff = Streamflow - Baseflow

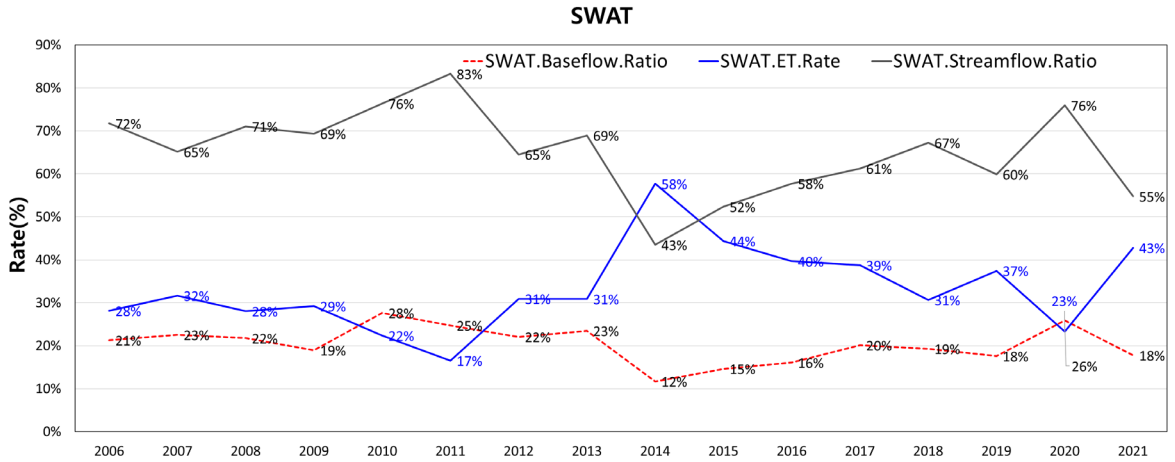


Surface Runoff Ratio(%)	2006~2014	2015~2021
SWAT	32%~59%(avg. 47%)	37%~50% (avg. 43%)
BFLOW	14%~61%(avg. 47%)	15%~45% (avg. 37%)

4. Conclusions

- ✓ **Evaluation of the reliability of long-term runoff simulation using the SWAT : R^2 = 0.759**
- ✓ **Analysis of hydrologic component**

SWAT Simulation results : **Evaporation rate Increasing,**
Runoff rate/ Baseflow rate slightly Decreasing



- ✓ **Future Research**
  - **Parameter Analysis -** Enhanced calibration techniques for improved simulation accuracy
  - **ML Integration -** Hybrid SWAT-ML models for better runoff predictions
  - **Climate Extremes -** Impact assessment of increasing extreme weather events

Thank you

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