SWAT Soil & Water Assessment Tool

Presentation for SWAT conference 2024

A comparison of the Reservoir Operational Module of SWAT and SWAT+ models in the Cedar Creek Watershed

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Water balance for reservoir

$$V = Vstored + Vflowin + Vpcp - V_{flowout} - Vseep - Veap$$

SWAT

$V_{flowout}$ *based on four methods*

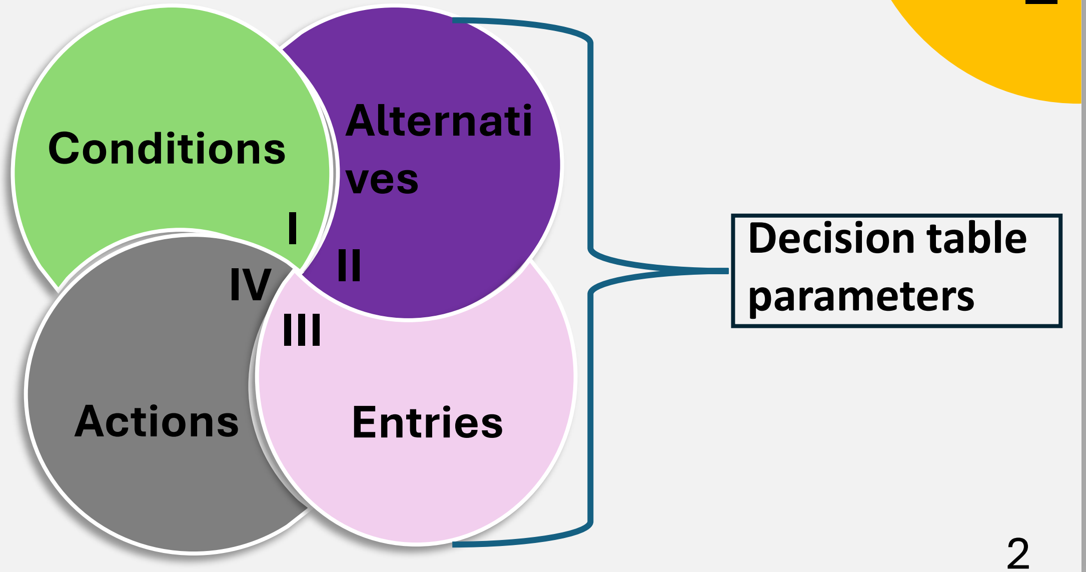
1. Measured daily outflow, $V = 86400.q_{out}$
2. Measured monthly outflow,
3. Average annual release rate for uncontrolled reservoirs
4. Controlled outflow with target release- mimic general release rules

❑ Sheng et al.,2023, Jingwen et al.,2020 etc

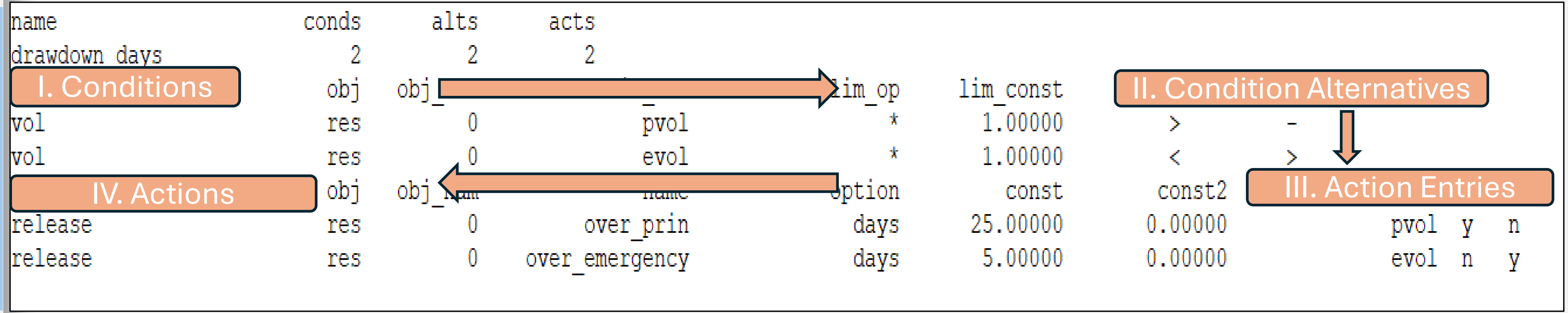
SWAT+

Releases based on the decision table

❑ Complex rules, actions



Default decision table for reservoir operation in SWAT+



name	conds	alts	acts							
drawdown_days	2	2	2							
	obj	obj_		lim_op	lim_const					
vol	res	0	pvol	*	1.00000	>	-			
vol	res	0	evol	*	1.00000	<	>			
	obj	obj_		option	const	const2				
release	res	0	over_prin	days	25.00000	0.00000		pvol	y	n
release	res	0	over_emergency	days	5.00000	0.00000		evol	n	y

Default decision table for reservoir operation in SWAT+

name	conds	alts	acts							
drawdown_days	2	2	2							
var	obj	obj_num	lim_var	lim_op	lim_const	alt1	alt2			
vol	res	0	pvol	*	1.00000	>	-			
vol	res	0	evol	*	1.00000	<	>			
act_typ	obj	obj_num	name	option	const	const2		fp	outcome	
release	res	0	over_prin	days	25.00000	0.00000		pvol	y	n
release	res	0	over_emergency	days	5.00000	0.00000		evol	n	y

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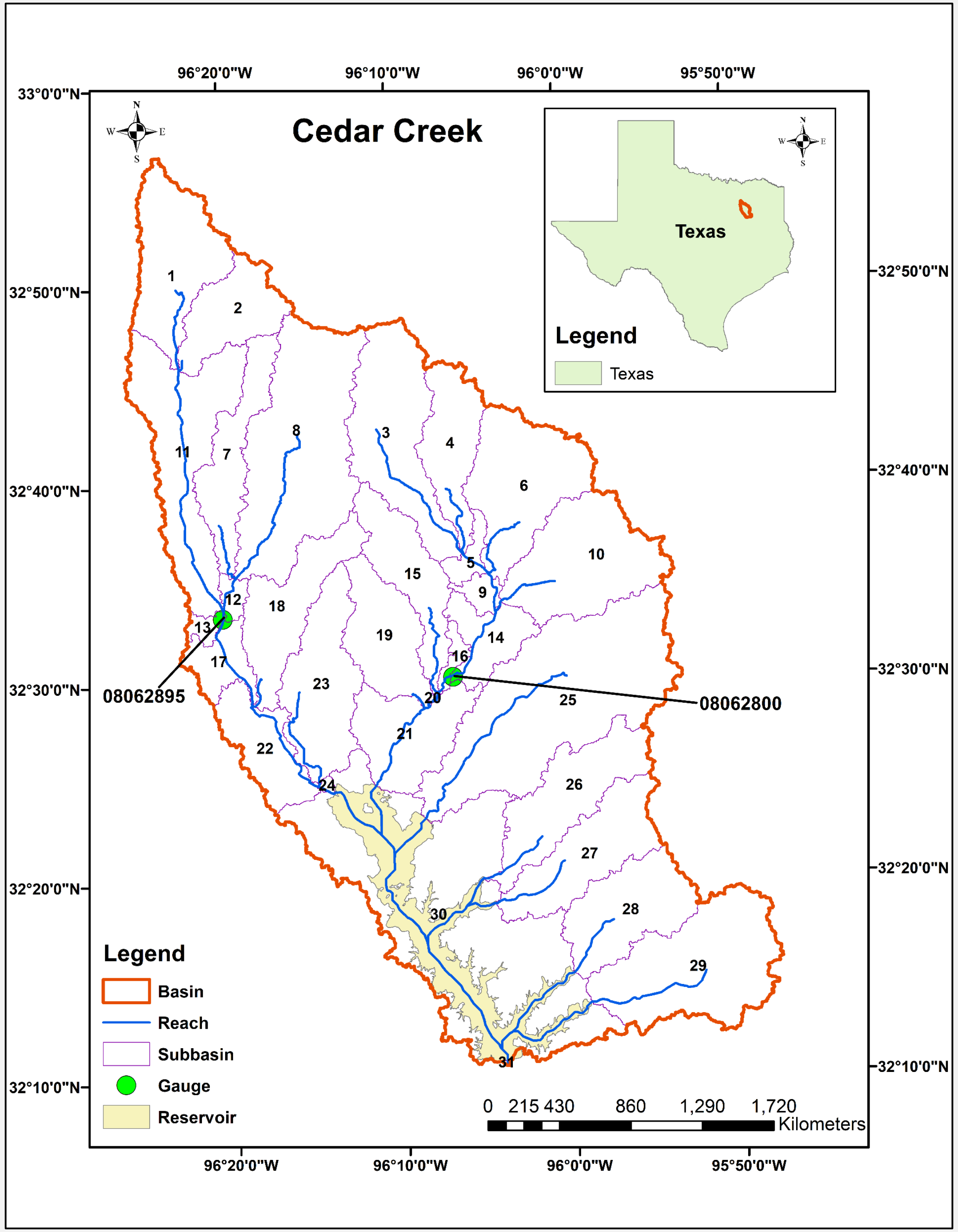
vol	res	0	pvol	*	1.00000	>	-			
vol	res	0	evol	*	1.00000	<	>			
act_typ	obj	obj_num	name	option	const	const2		fp	outcome	
release	res	0	over_prin	days	25.00000	0.00000		pvol	y	n
release	res	0	over_emergency	days	5.00000	0.00000		evol	n	y

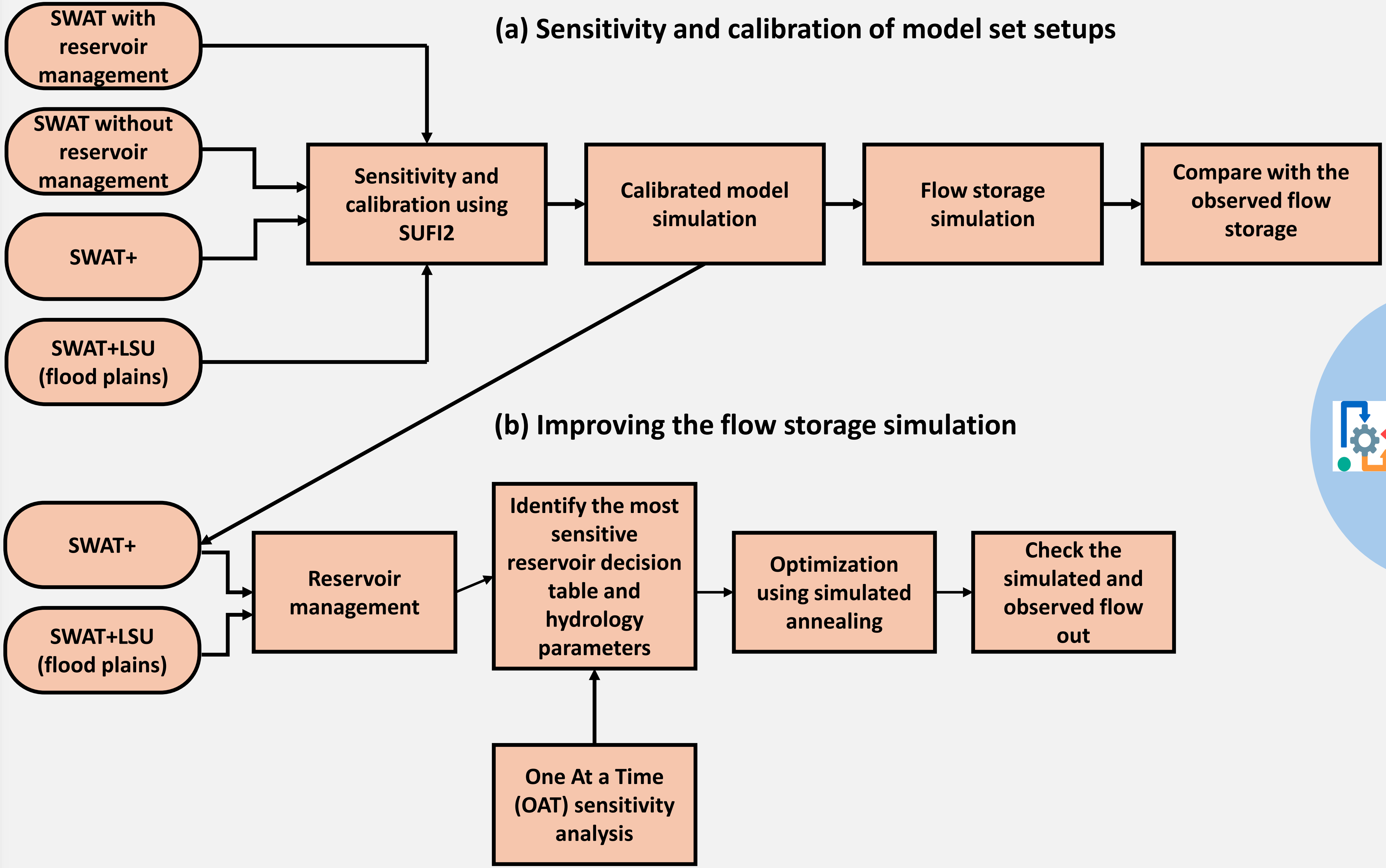
Motivation:

- ❖ **Propose a methodology to improve the reservoir simulations where we are unaware of specific operational policies.**
- ❖ **Improve the flow release by adjusting the decision table and reservoir hydrology parameters up to a plausible range in SWAT+**

- Cedar Creek watershed is located southeast of **Dallas, North Central Texas**.
- The catchment area is around **2624** km^2
- Part of the Trinity River basin and eventually discharges to the Gulf of Mexico

SI	Data	Source	Remarks
1	PPT and T (2003-2021)	PRISM Gridded	4km x 4km
2	LULC (2014)	NLCD	30m x 30m
3	DEM	SRTM	30m x 30m
4	SOIL	SURGGO	10m x 10m




(a) Sensitivity and calibration of model set setups
SWAT with reservoir management
SWAT without reservoir management
SWAT+
SWAT+LSU (flood plains)
Sensitivity and calibration using SUFI2
Calibrated model simulation
Flow storage simulation
Compare with the observed flow storage
(b) Improving the flow storage simulation
SWAT+
SWAT+LSU (flood plains)
Reservoir management
Identify the most sensitive reservoir decision table and hydrology parameters
Optimization using simulated annealing
Check the simulated and observed flow out
One At a Time (OAT) sensitivity analysis

Optimization of decision table parameters using simulated annealing (SWAT+)

```
name                 conds    alts    acts
drawdown_days            2       2       2
var                    obj  obj_num         lim_var     lim_op   lim_const    alt1    alt2
vol                    res        0            pvol          *     1.00000       >       -
vol                    res        0            evol          *     1.00000       <       >
act_typ                obj  obj_num            name     option       const  const2              fp  outcome
release                res        0       over_prin       days    25.00000  0.00000           pvol  y  n
release                res        0  over_emergency       days     5.00000  0.00000           evol  n  y
```

Parameter 1

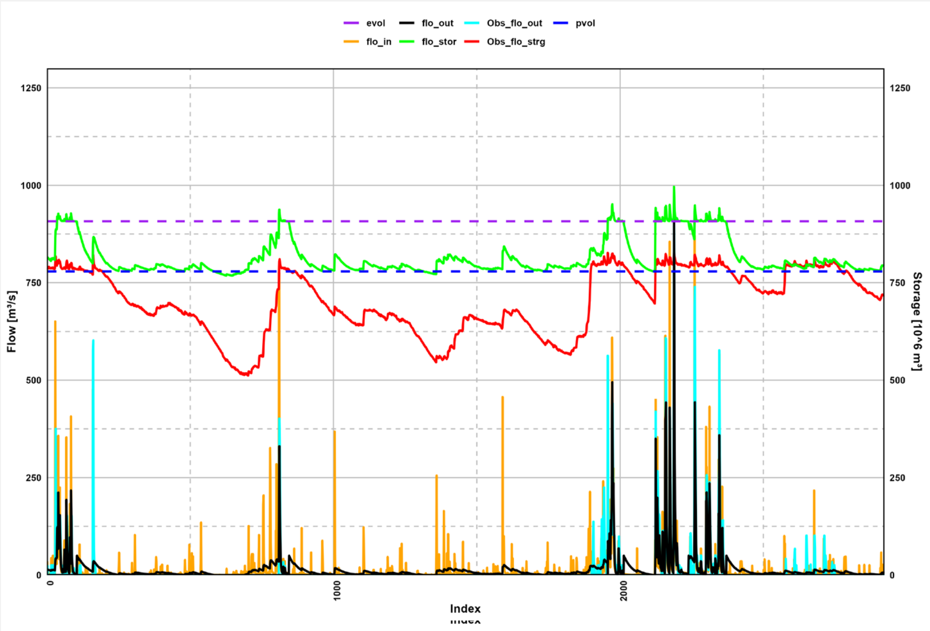
Parameter 2

Parameter 3

- Sensitivity was tested using OAT
- Selected three decision table parameters

Parameters	Min	Max
Parameter 1	0.8	1.2
Parameter 2	0.9	1
Parameter 3	15	35
Parameter 4	0	0.2
Parameter 5	0.6	0.8

- Incorporated seepage and evapotranspiration loss in the hydrology.res file
- K (Parameter 4) and evap_co (Parameter 5)

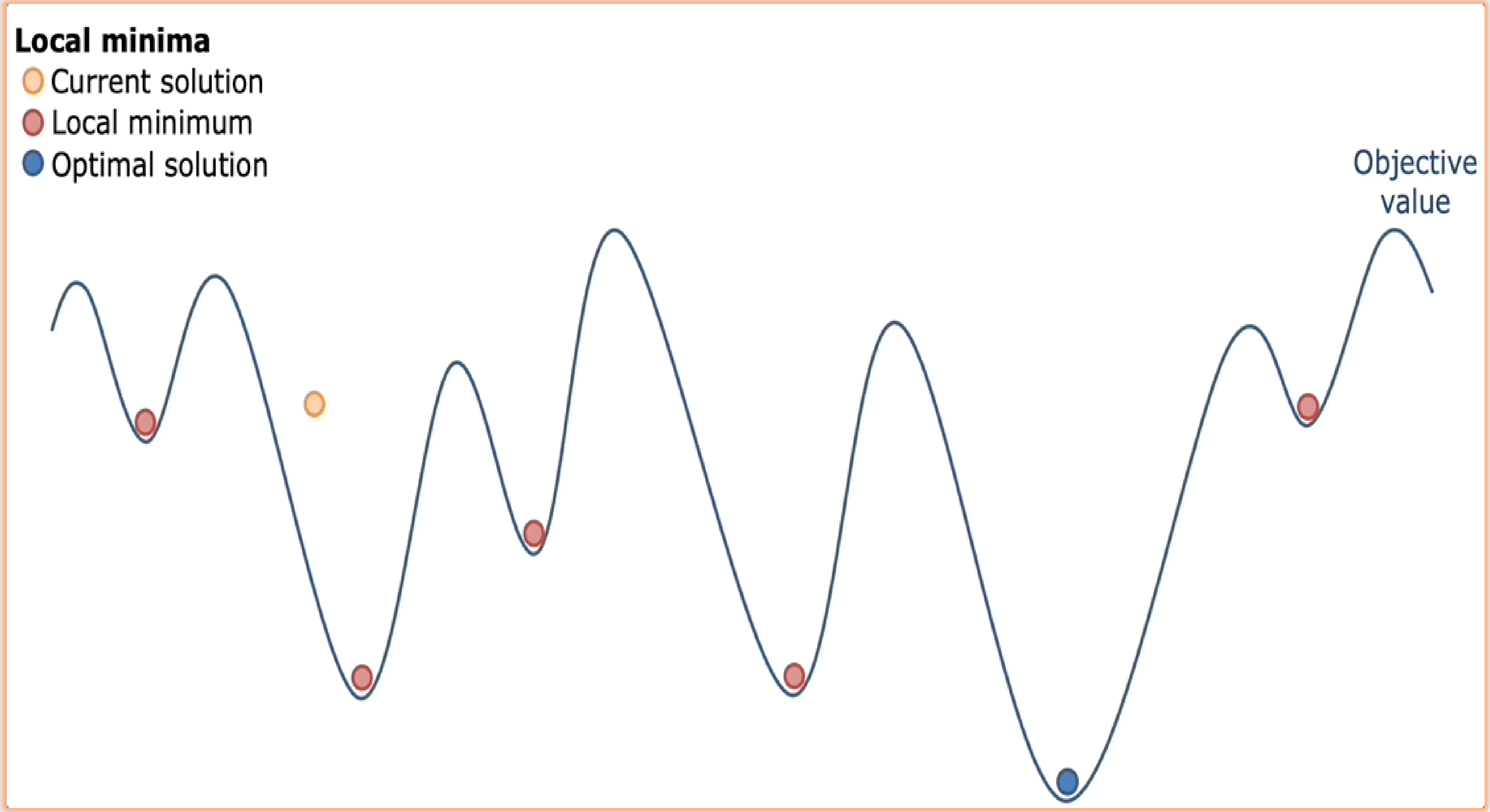


Conclusions

Methodology

Introduction

Search space of Simulated Annealing



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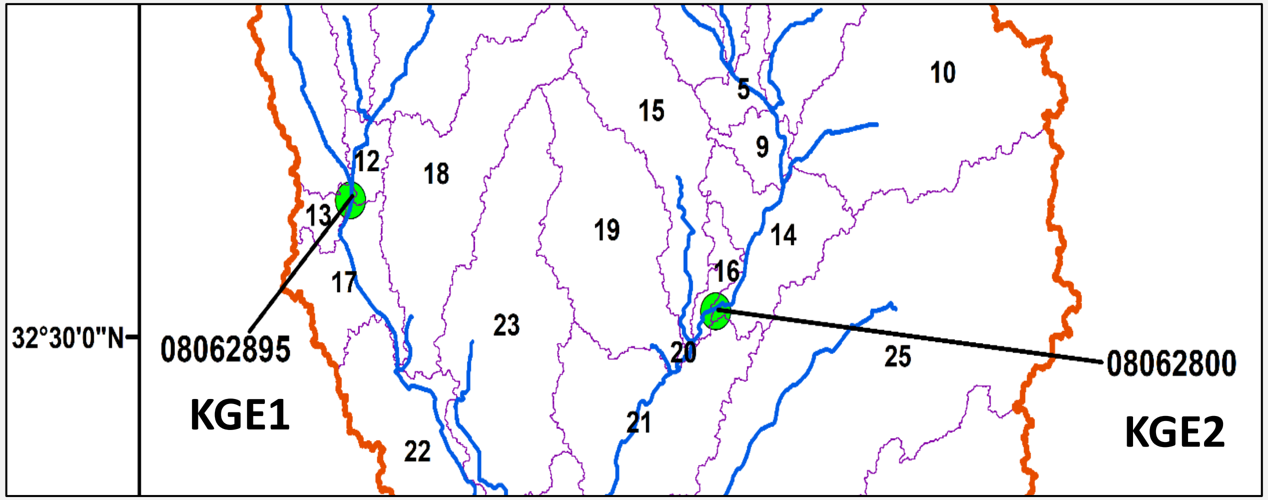
Watershed configuration and default model performance

SL No	Specification	SWAT	SWAT+	SWAT+ LSU
1	LULC/SOIL/SLOPE	2/10/10	2/10/10	2/10/10
2	HRU	959	2602	4086
3	Subbasin	31	36	36
4	LSU	---------	79	154

Gauge ID	Model	KGE (2010_2017)	NSE
08062895	SWAT	0.48	0.41
	SWAT+	0.48	0.40
	SWAT+LSU	0.46	0.41
08062800	SWAT	0.23	0.01
	SWAT+	0.16	0.19
	SWAT+LSU	0.14	0.21

Sensitivity analysis

$$\text{OF} = \frac{KGE1+KGE2}{2}$$



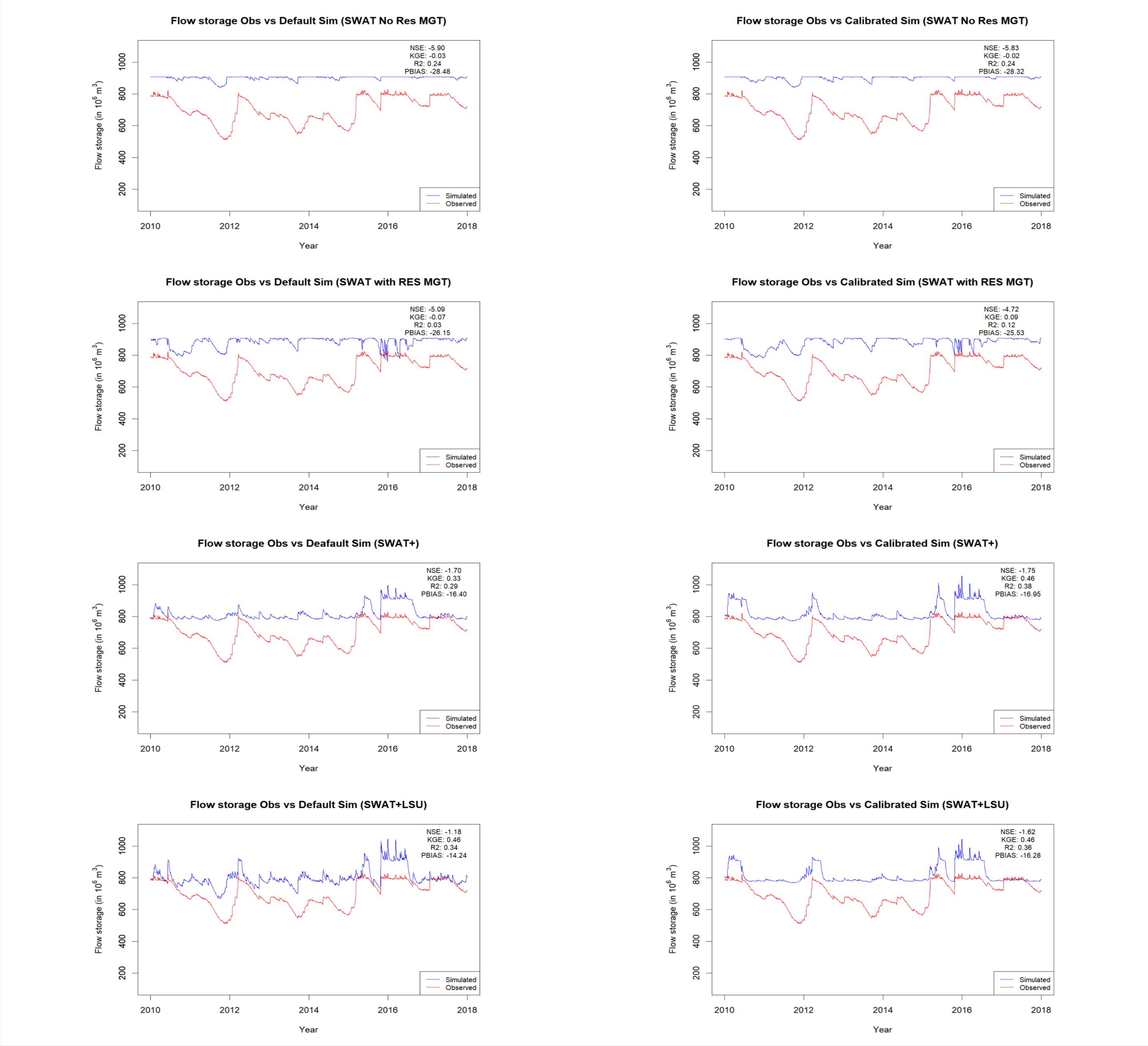
Global Sensitivity analysis results

SWAT	SWAT+	SWAT+LSU
CN2	cn3_swf	cn3_swf
SURLAG	cn2	cn2
SOL_K	esco	esco
CANMX	epco	epco
SLSOIL	surlag	surlag
HRU_SLP	awc	awc
ALPHA_BF	z	z
RCHRG_DP	bd	bd
SMTMP	revap_co	slope
SMFMX	deep_seep	Snomelt_tmp

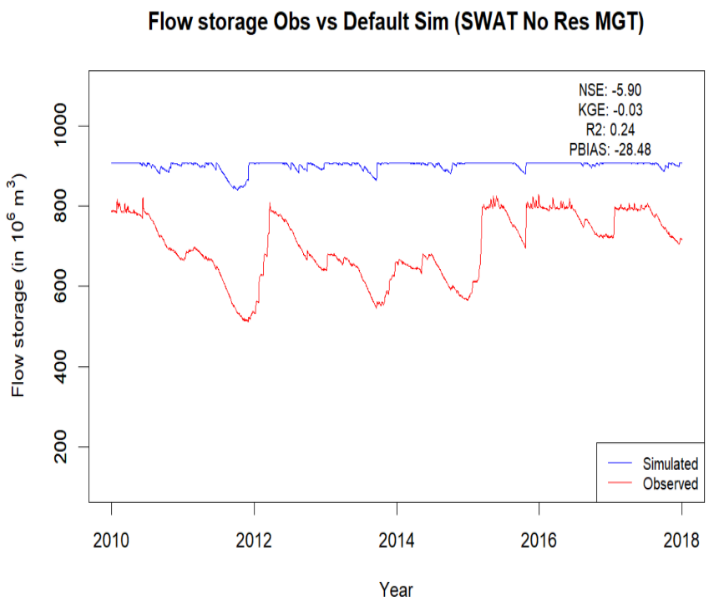
Calibration analysis results

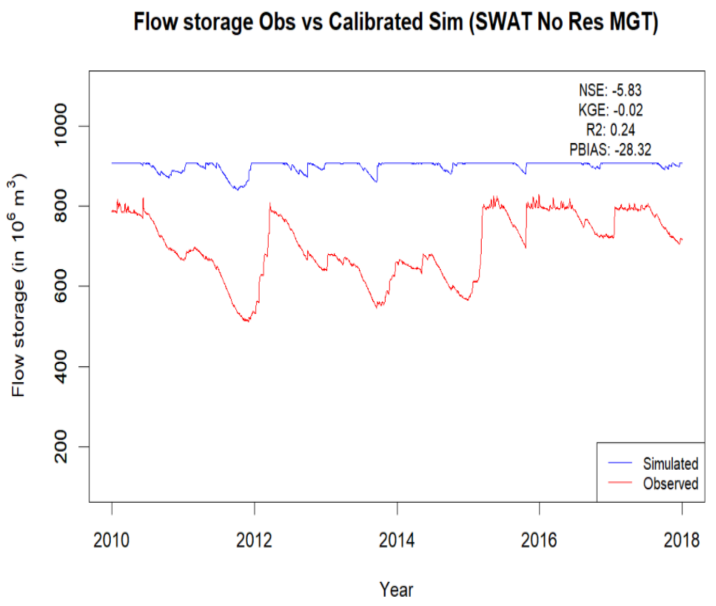
Model	Calibration KGE	Validation KGE
SWAT	0.52	0.57
SWAT+	0.56	0.50
SWAT+LSU	0.60	0.57

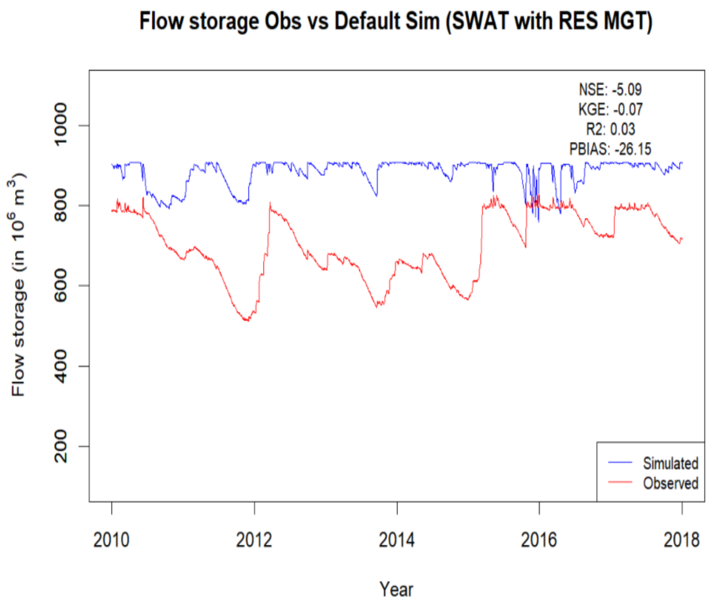
Validation of flow storage for different model setup

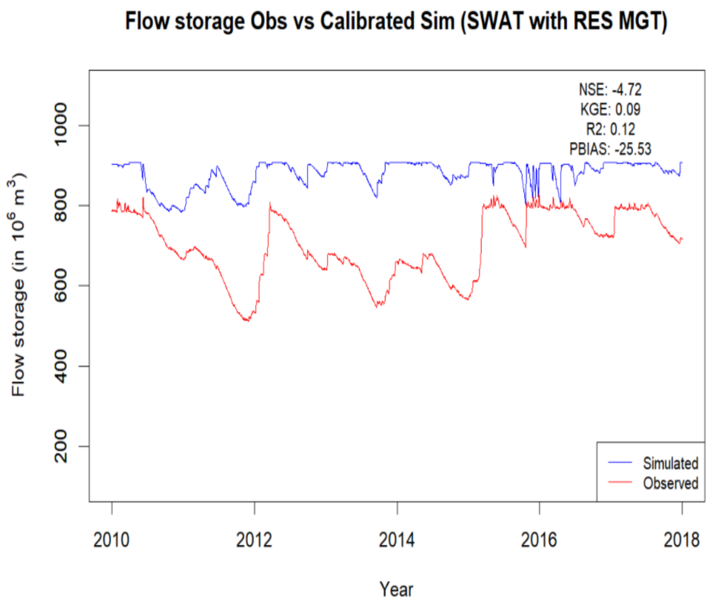


Validation of flow storage for different model setup









Validation of flow storage for different model setup

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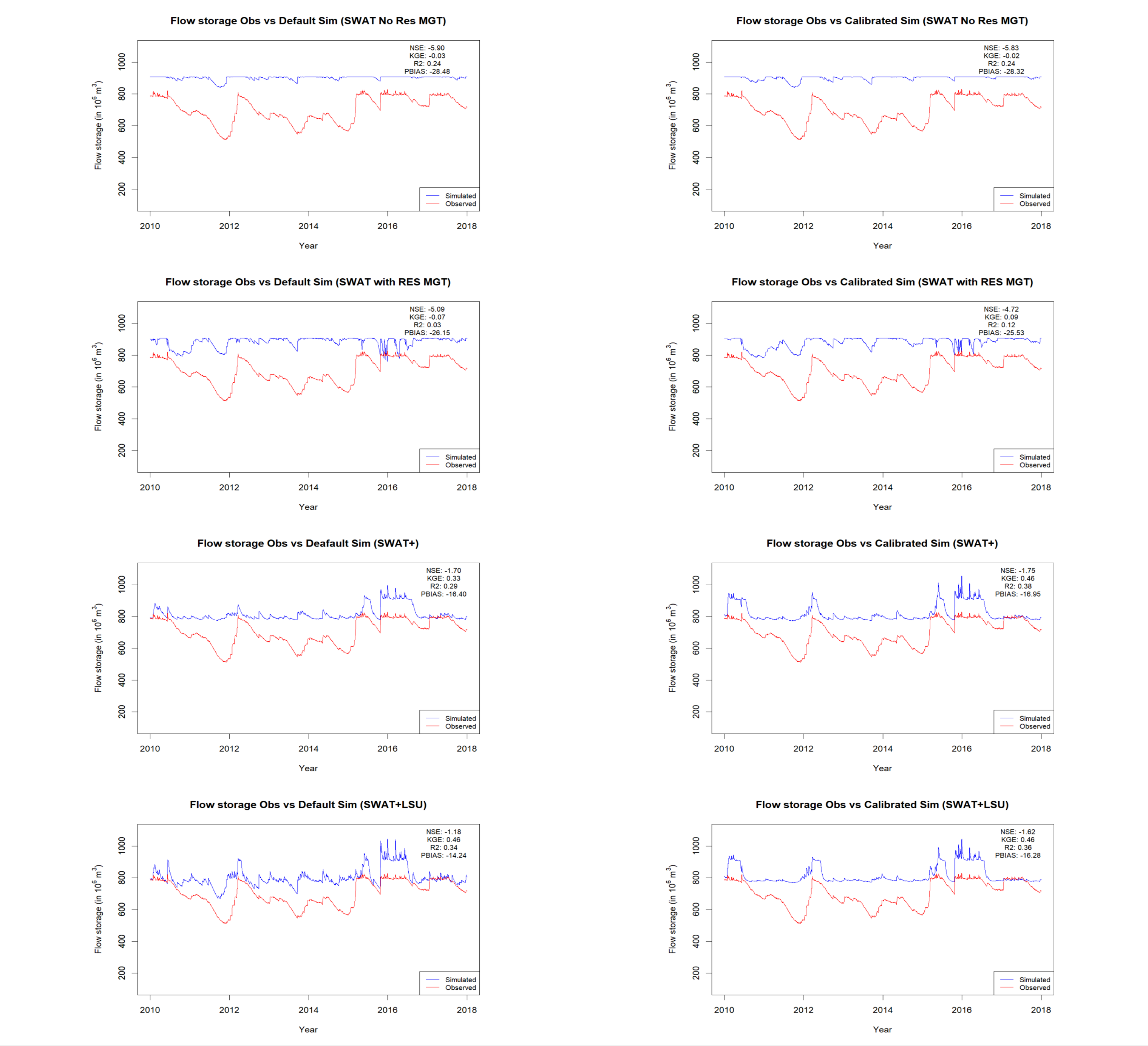
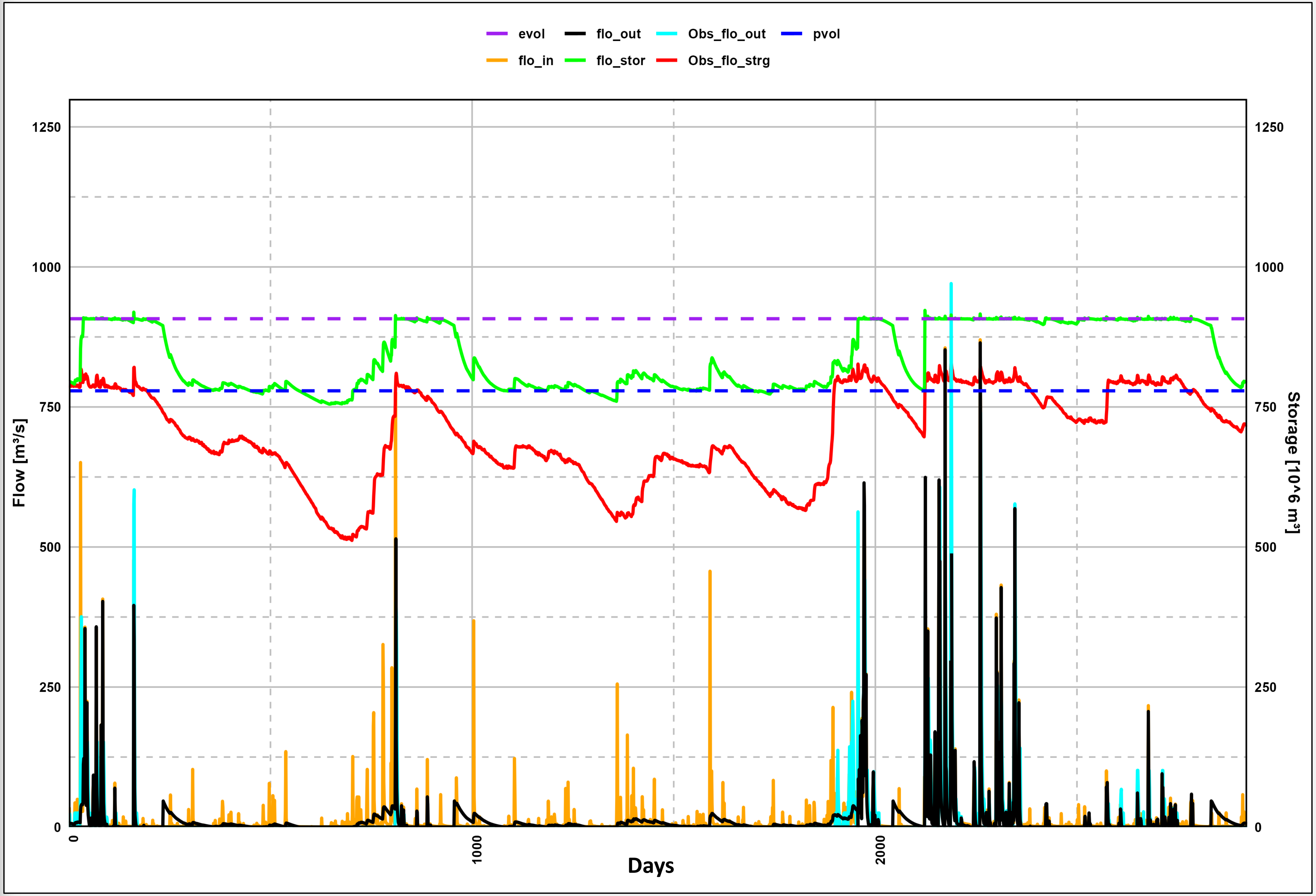
Validation of flow storage for different model setup

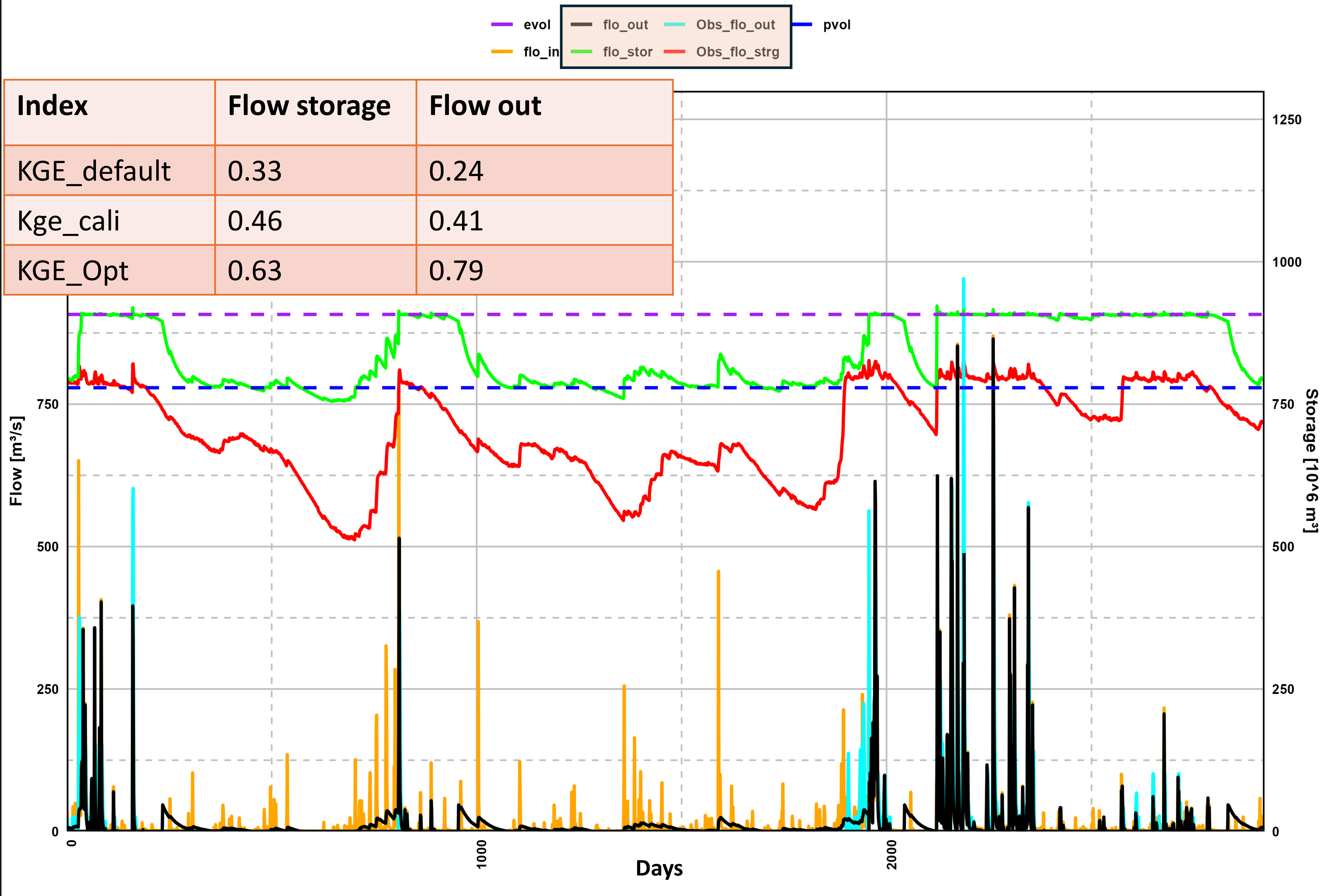


Optimized parameters using simulated annealing (SWAT+)

Parameters	Min	Max	Optimized parameter
Parameter 1	0.8	1.2	0.8879
Parameter 2	0.9	1	0.987
Parameter 3	15	35	29
Parameter 4	0	0.2	0.132
Parameter 5	0.6	0.8	0.776


evol
flo_out
Obs_flo_out
pvol
flo_in
flo_stor
Obs_flo_strg
Flow [m³/s]
Storage [10^6 m³]
Days
1250
1000
750
500
250
0
1000
2000

Index	Flow storage	Flow out
KGE_default	0.33	0.24
Kge_cali	0.46	0.41
KGE_Opt	0.63	0.79



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- Incorporation of a decision table in the reservoir module of SWAT+ improved reservoir simulation as compared with the SWAT model.
- Default decision table operation parameters must be adjusted for better reservoir simulation.
- Simulated annealing served as a good algorithm for finding the optimized values of different parameter set.
- This method can be adopted when you don’t have a rule curve for the reservoir operations.

Future scope

Methodology

Introduction

- Incorporation of machine learning techniques to capture the observed flow storage pattern and adjust the decision table parameters.
- Use the observed hydrologic inflow to the reservoir data for better calibration and validation, because hydrologic inflows are overestimated in the current study