HYDROLOGICAL SIMULATION OF A TEMPERATE WATERSHED IN CENTRAL DENMARK USING SWAT+

Anandita Agarwal, Phd candidate

28th June, Swat+ conference 2023, Aarhus university, Denmark

AARHUS UNIVERSITET

The EU Framework Programme for Research and Innovation

HORIZON 2020

invent water

SWAT+

SOIL & WATER ASSESSMENT TOOL

BACKGROUND

- The Intergovernmental Panel on Climate Change (IPCC) report reaffirms that "global warming" is occurring (AR6, IPCC, 2023).

- Global climate change is increasingly becoming a key issue in water management all over the world.

- For the adaptation to climate change as a fixed fact in the future, watershed decision makers require quantitative results for the establishment of strategy.

OUTLINE

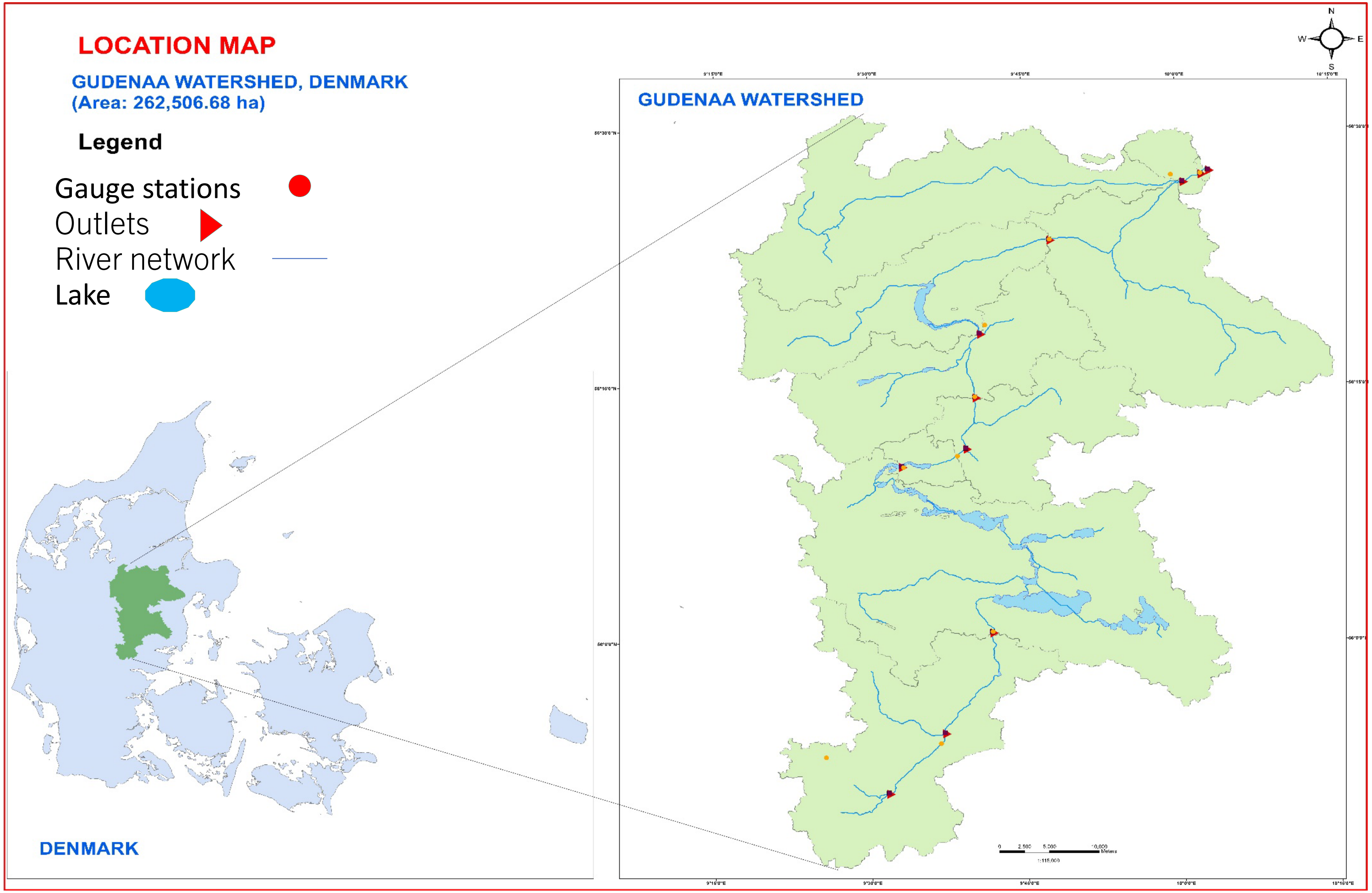
- Model set up
- Initial results & Water balance Analysis
- Parametrization

OBJECTIVE

- To develop scalable innovative forecasting tool
- Application for water management in GW dominant catchment as well as providing mitigation in areas such as floods in central Denmark.

STUDY AREA

- Gudenå river catchment in Denmark.
- Area : 262,506.68-ha
- Climate > Temperate > **Annual Precipitation** of 803 mm.
- Winter (October-April) and Summer (May-September)
- Annual Mean **temperature** of 3.7 and 14.5°C, respectively.



DATASETS: PREPARATION OF INPUT

Data Set	Source	Scale	Data Description / Properties
DEM	Earth Explorer system by USGS	50m	SRTM digital elevation map , 1 Arc second
Soil	https://www.wateritech.com/data	250m	OpenLandMap soil map; the map includes six soil layers.
Land use	https://www.wateritech.com/data	100m	Corine Landuse map; Copernicus Land Monitoring Service (CLMS) provides the CORINE Land Cover (CLC) dataset, inventory of 44 land cover classes.
Weather	ERA5 data from Wateritech data portal http://test.asap-forecast.com:3000/	Daily	Precipitation, minimum and maximum temperature, mean wind speed, relative humidity and solar radiation data from 1979 to 2020.
	DMI data AU server (Danish metrological institute)		
Streamflow	https://odaforalle.au.dk/	Daily	Streamflow data from 11 gauging stations.

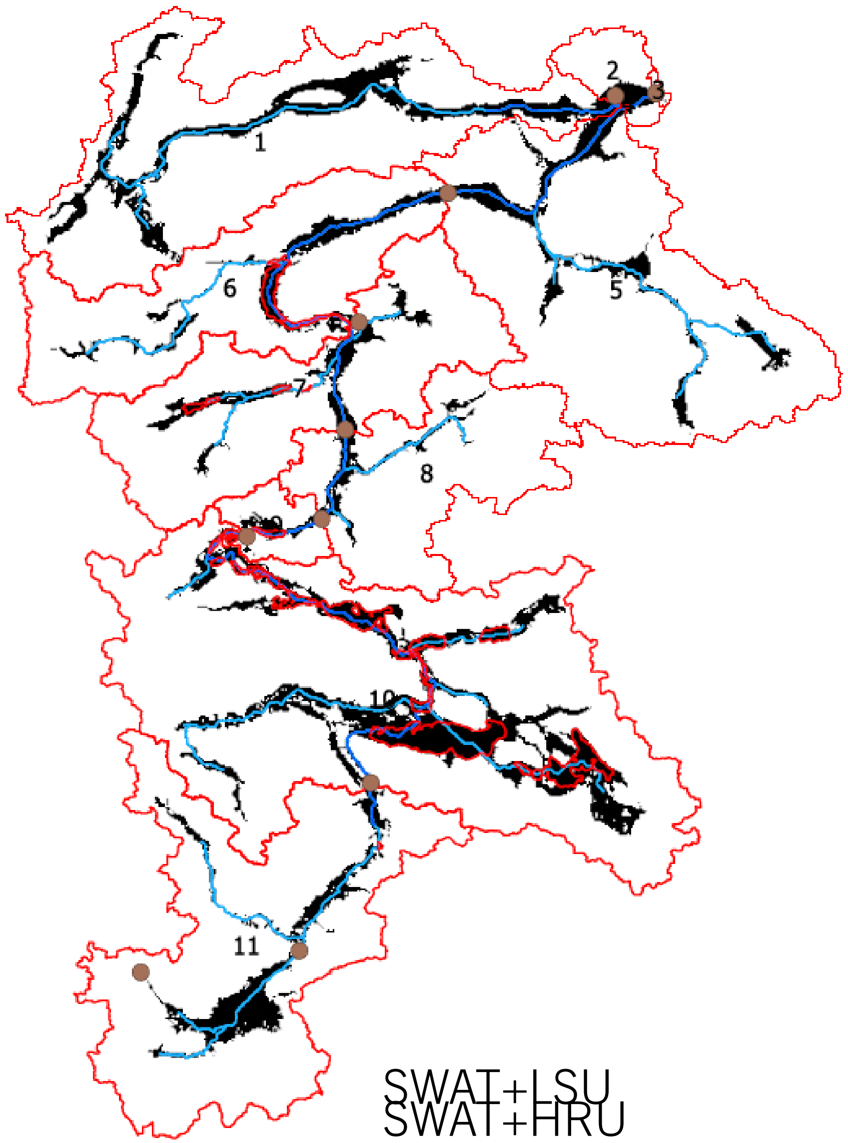
SWAT+ MODEL SETUP

We assessed the performance of two SWAT+ model setups :

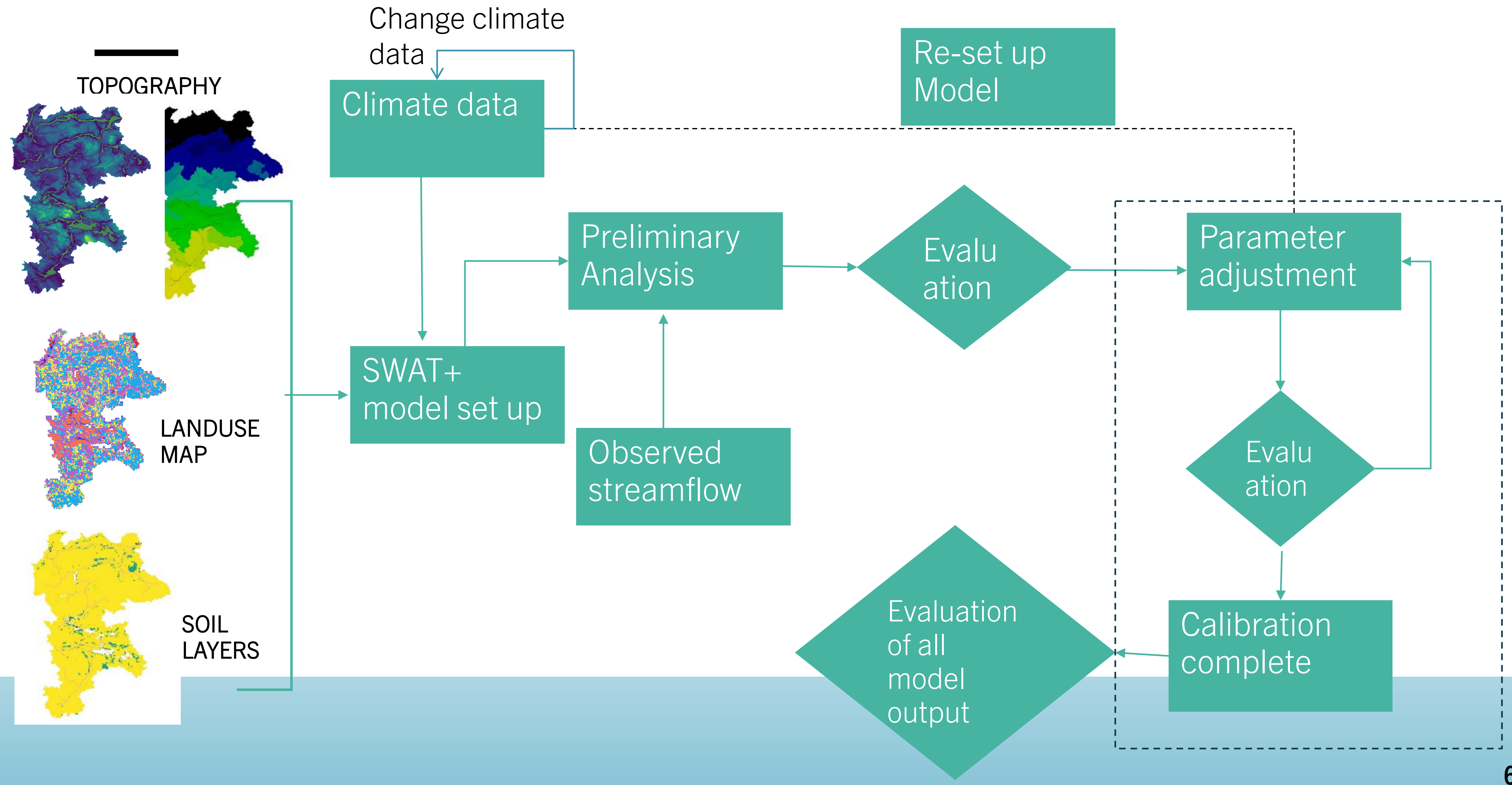
SWAT+LSU: runoff is routed from the upland to the floodplain areas of a subbasin, before it reaches the stream.

SWAT+HRU: runoff from hydrological response units (HRUs) is summed up at the subbasin level and added directly to the stream.

Several code versions of SWAT+ have been tested, and the model has undergone initial calibration.



MODELLING EVALUATION



SWAT+ LSU SIMULATION

- First simulation (before calibration)

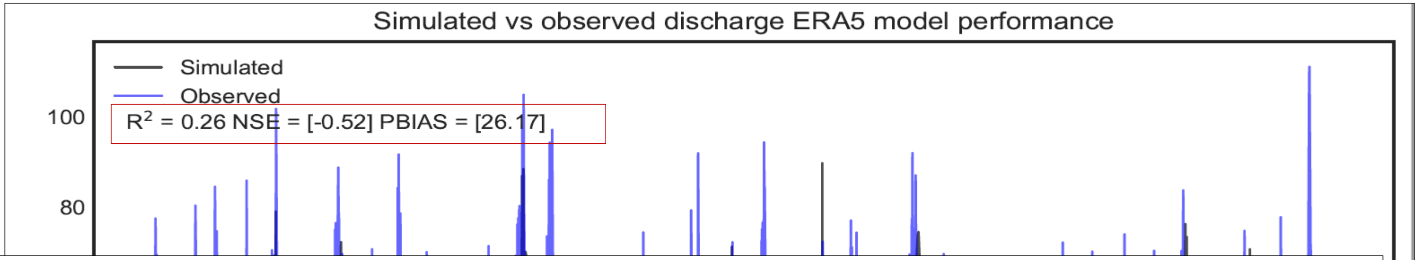
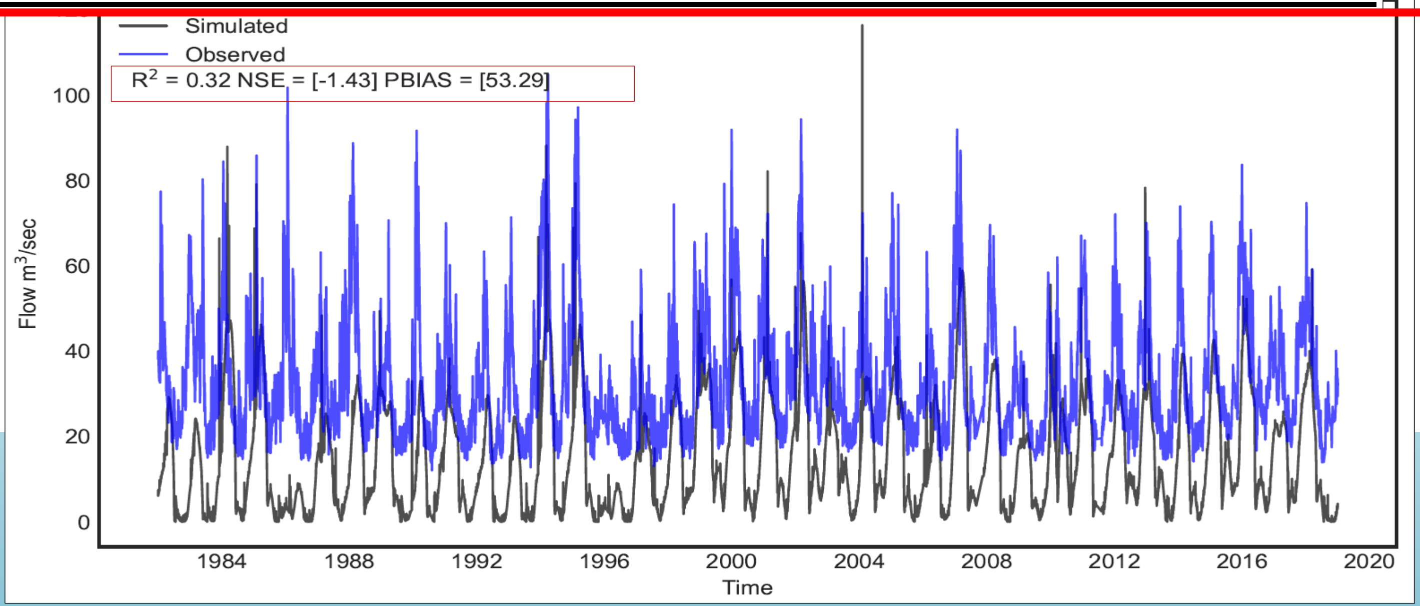


Table 4. General performance ratings for recommended statistics for a monthly time step.

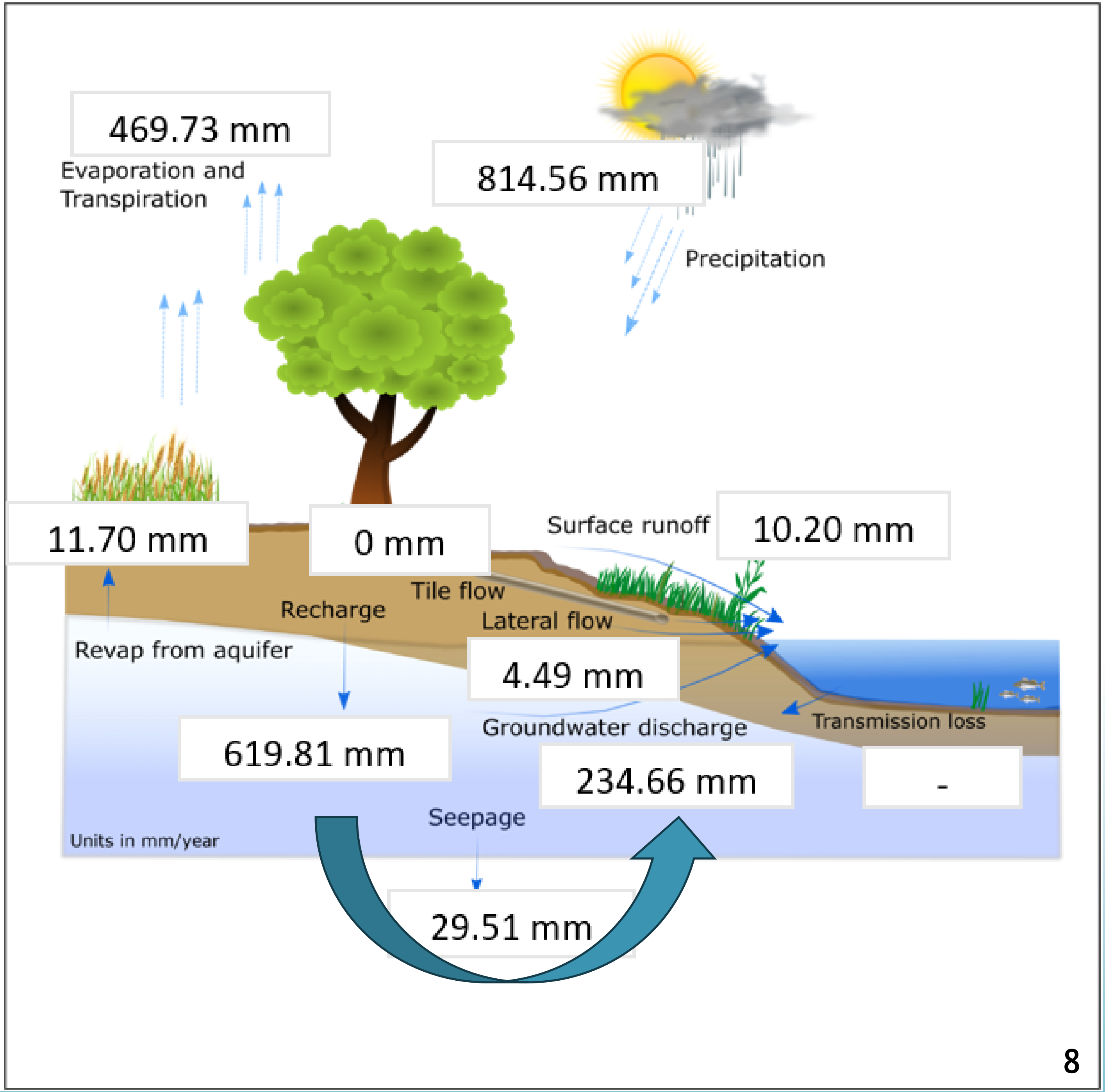
Performance Rating	RSR	NSE	PBIAS (%) Streamflow	PBIAS (%) Sediment	PBIAS (%) N, P
Very good	0.00 ≤ RSR ≤ 0.50	0.75 < NSE ≤ 1.00	PBIAS < ±10	PBIAS < ±15	PBIAS< ±25
Good	0.50 < RSR ≤ 0.60	0.65 < NSE ≤ 0.75	±10 ≤ PBIAS < ±15	±15 ≤ PBIAS < ±30	±25 ≤ PBIAS < ±40
Satisfactory	0.60 < RSR ≤ 0.70	0.50 < NSE ≤ 0.65	±15 ≤ PBIAS < ±25	±30 ≤ PBIAS < ±55	±40 ≤ PBIAS < ±70
Unsatisfactory	RSR > 0.70	NSE ≤ 0.50	PBIAS ≥ ±25	PBIAS ≥ ±55	PBIAS ≥ ±70



- Both have unsatisfactory performance but ERA5 does slightly better than DMI.
- High underestimation of base flow.

WATER BALANCE ERA,SWAT+LSU

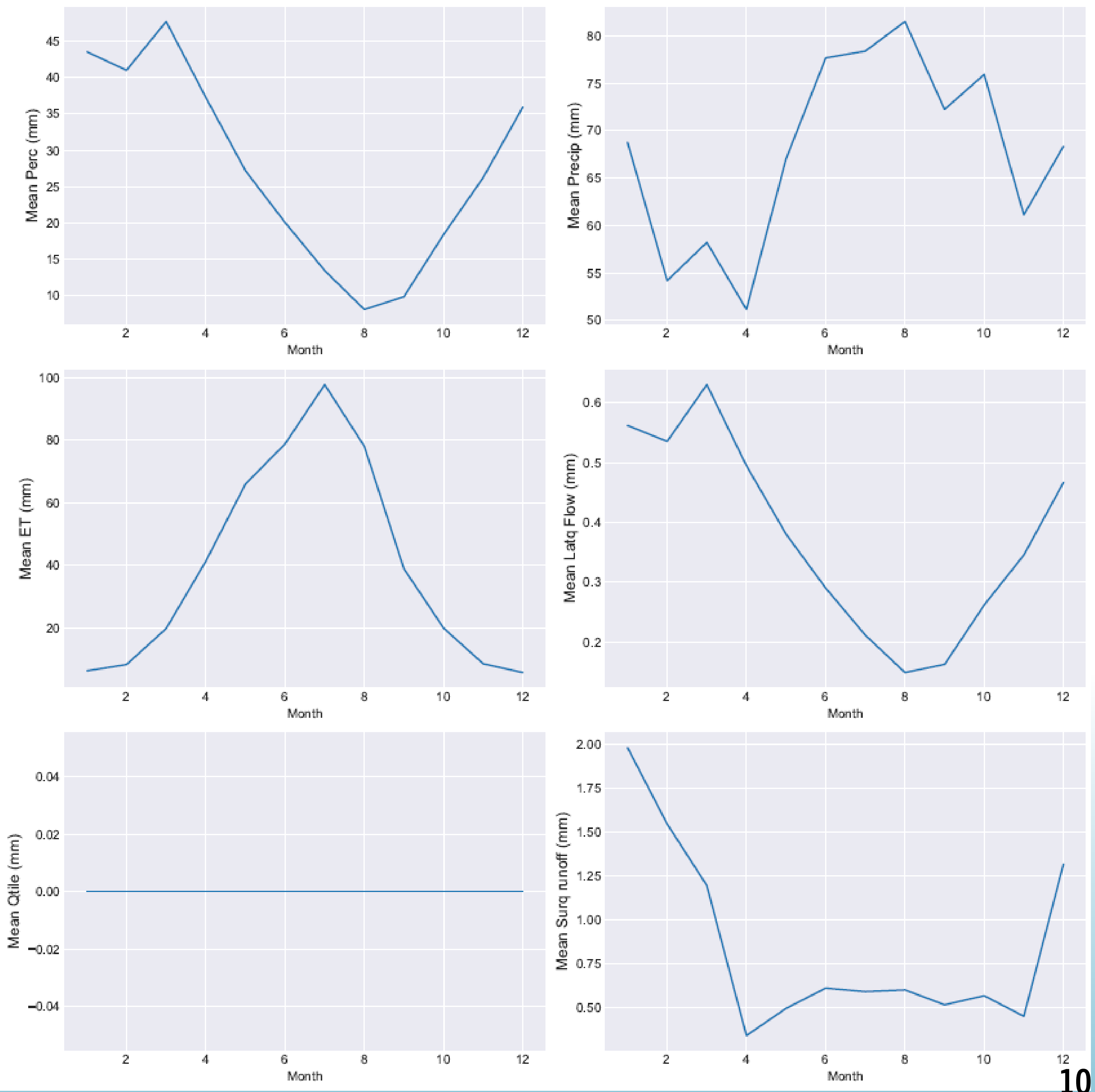
- 2/3 of water is missing from the recharge amount as only 1/3 is turning up as gw discharge (before calibration).
- Need to analyze ET, Lateral Flow and Ground water flow components.



WB COMPONENTS

Mean monthly distribution of water balance components in model configuration for the entire model run

- Ratio of evapotranspiration & precipitation:
  - Et/P <1 (0.576666)
- Surq is low and Perco is high
- Latq < 4mm per month = negligible impact
- No tile drainage.
- Percolation and associated GW contribution is underestimated in current simulation.

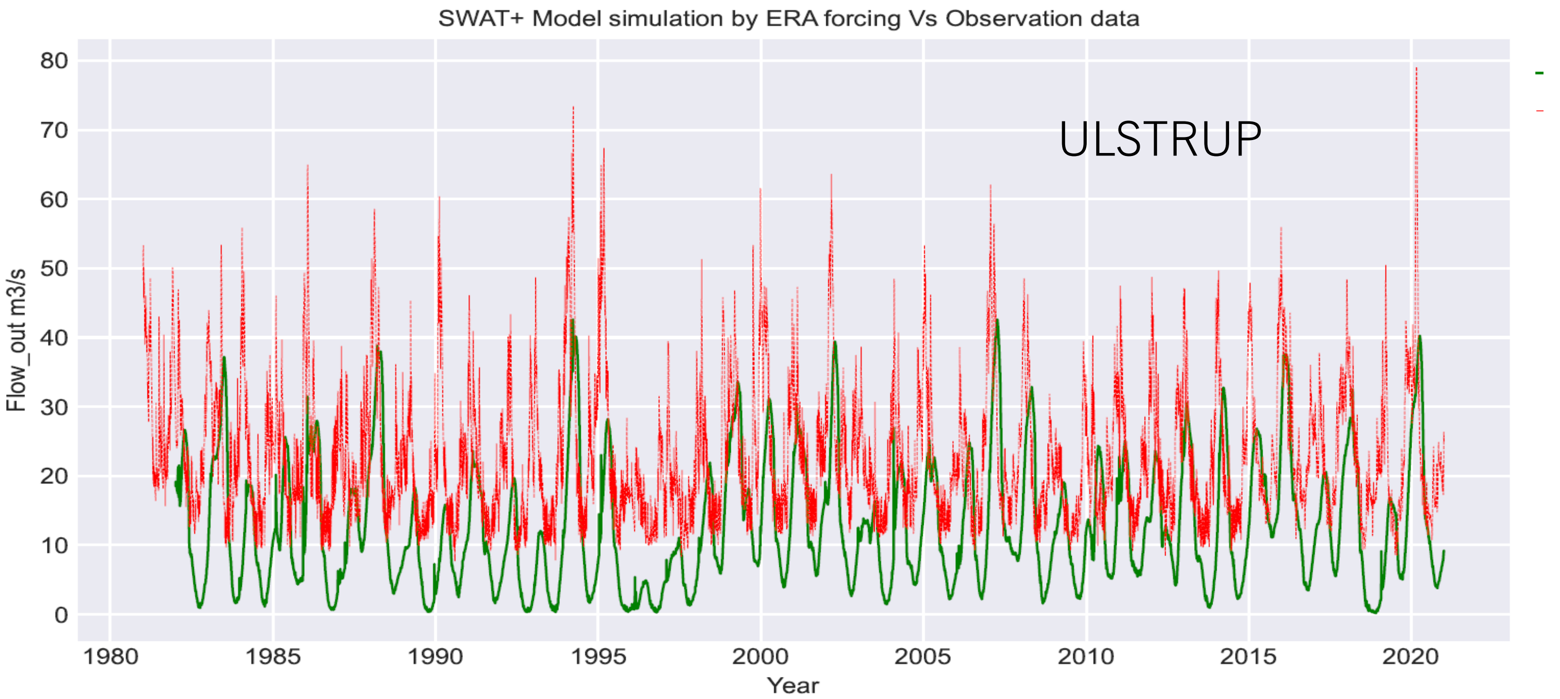


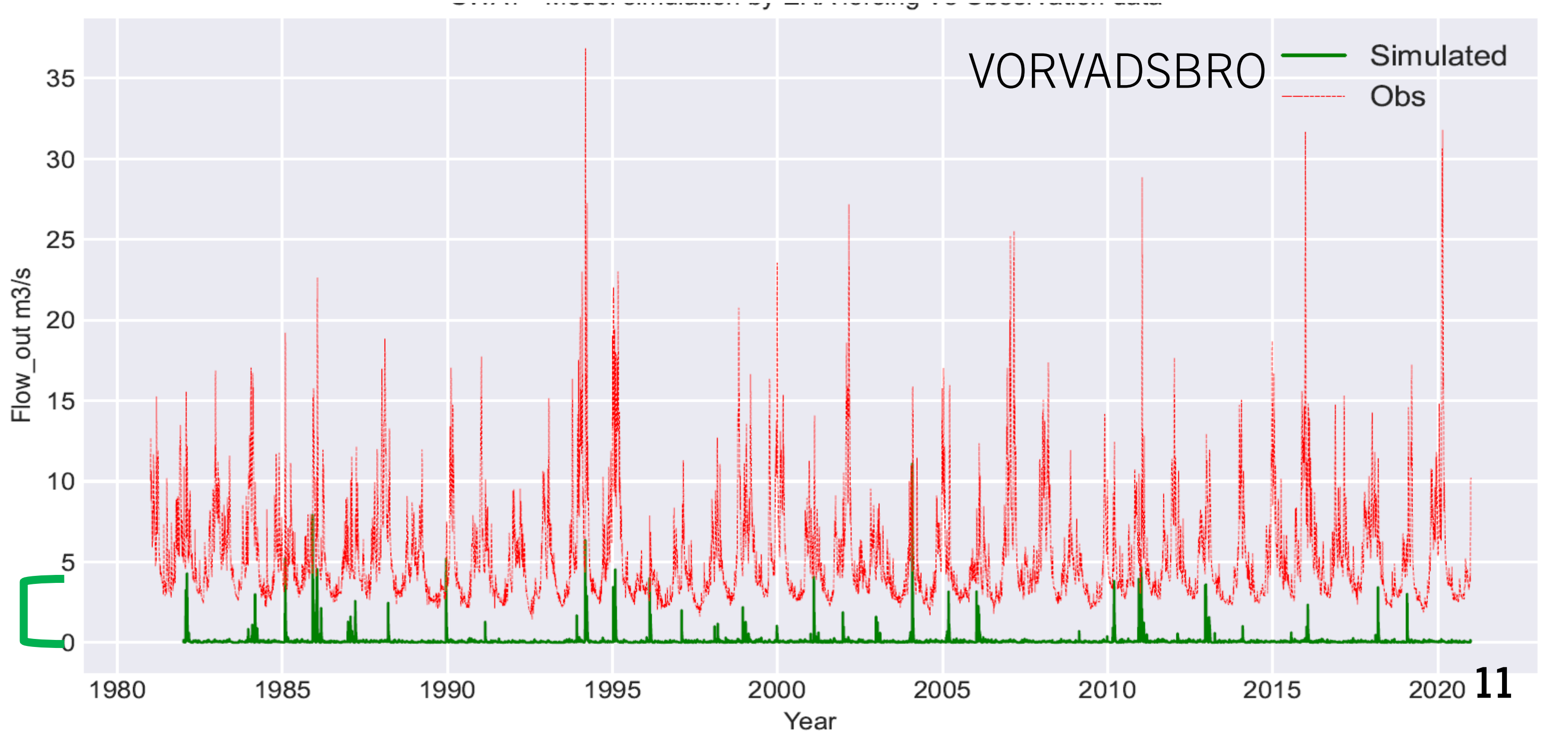
UPSTREAM STREAMFLOW GRAPH

Upstream simulation shows substantial amount of water missing.

Routing of water from landscape to main channel needs to explored.

GW playing a crucial role but how to model it?



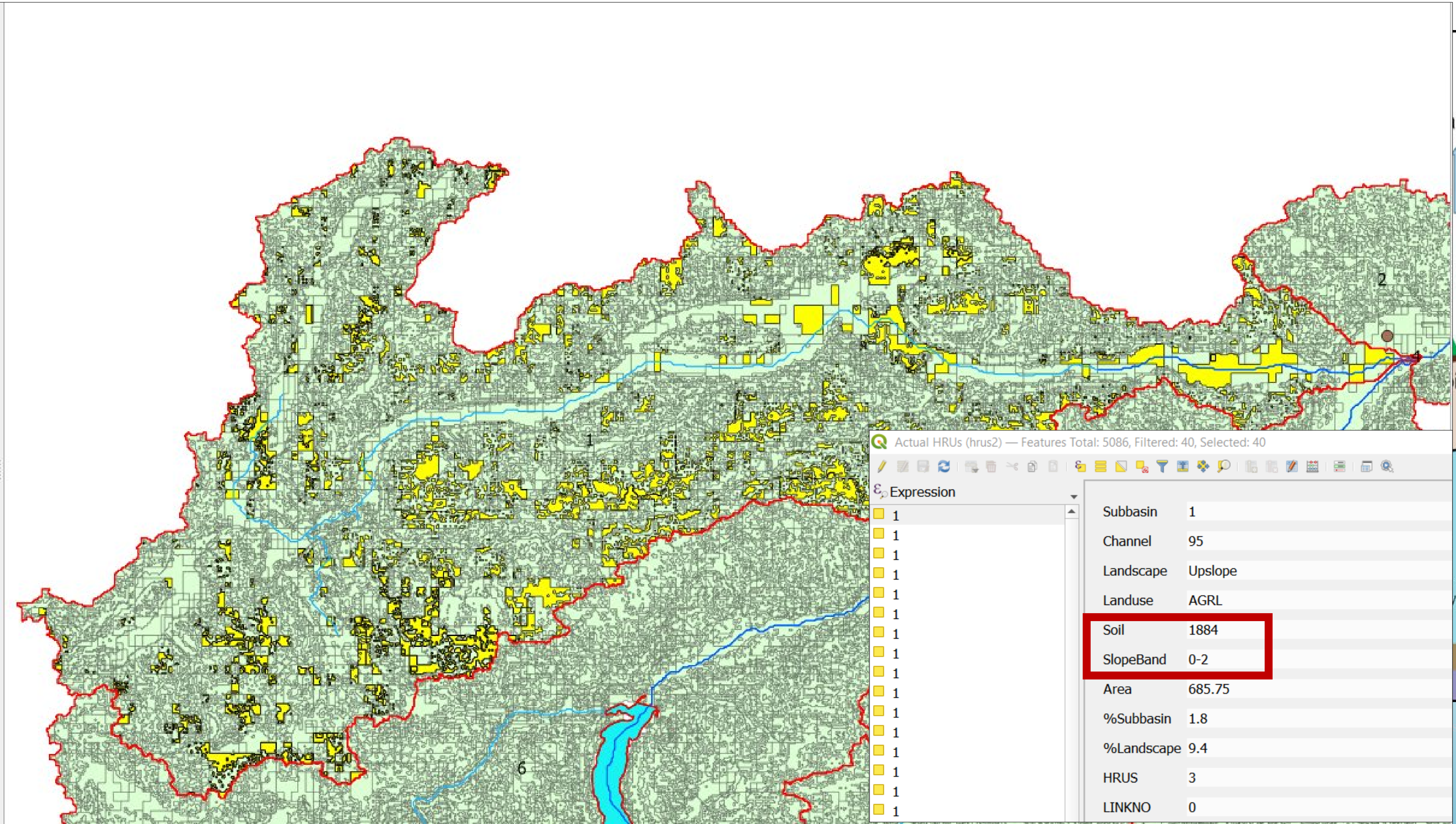


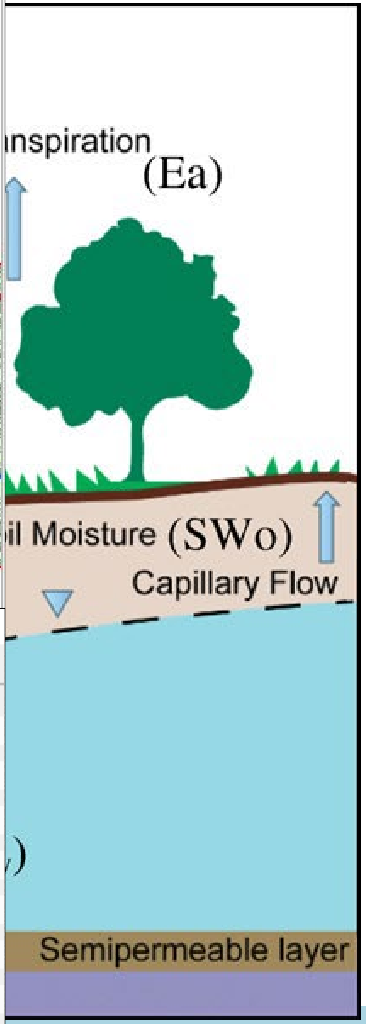
SENSITIVITY ANALYSIS

- Distributed models involve many parameters.
- Dealing with all these parameters at calibration stage is very time intensive and difficult.
- So, to ensure efficient calibration , sensitivity analysis was carried out for filtering out most influential parameters using literature review and expert guidance.

Ranking	Parameter	Explanation
1	CN2	Initial SCS CN2 value (.hru)
2	K	Soils saturated hydraulic conductivity(.sol)
3	AWC	Soil available water capacity(.sol) **(mm H_2O/mm)**
4	BF_MAX	Maximum Baseflow alpha factor
5	FLO_MIN	Minimum aquifer storage to allow to return flow (m)
6	ESCO	Soil evaporation compensation factor (.hru)
7	EPCO	Plant uptake compensation factor (.hru)
8	CN3_SWF	Soil water factor for cn3
9	PERCO	Percolation coefficient-adjusts soil moisture for percolation to occur
10	LATQ_CO	Lateral soil flow coefficient -linear adjustment to daily lateral flow
11	ALPHA	Baseflow recession constant(.aqu)

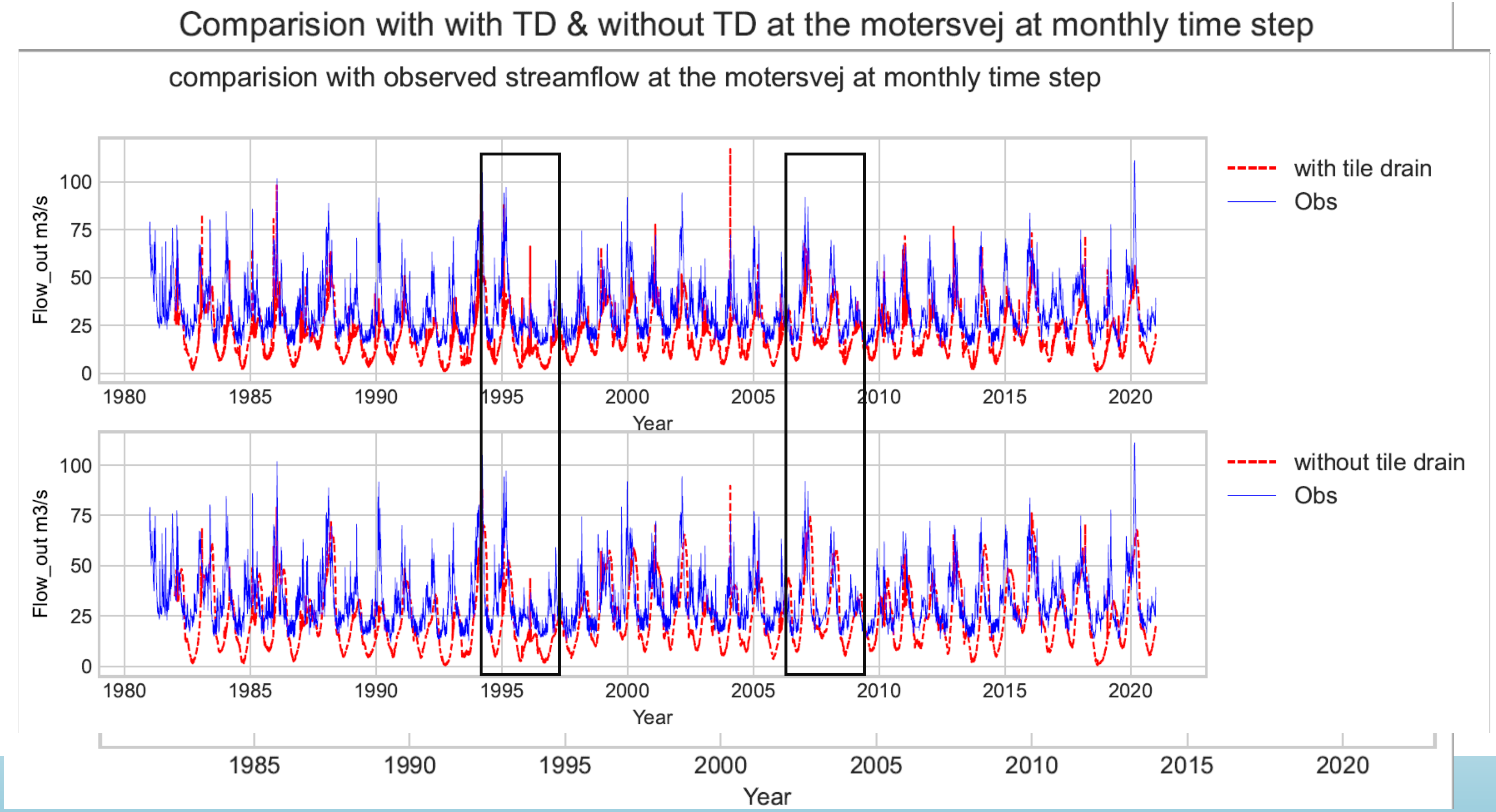
PARAMETRIZATION





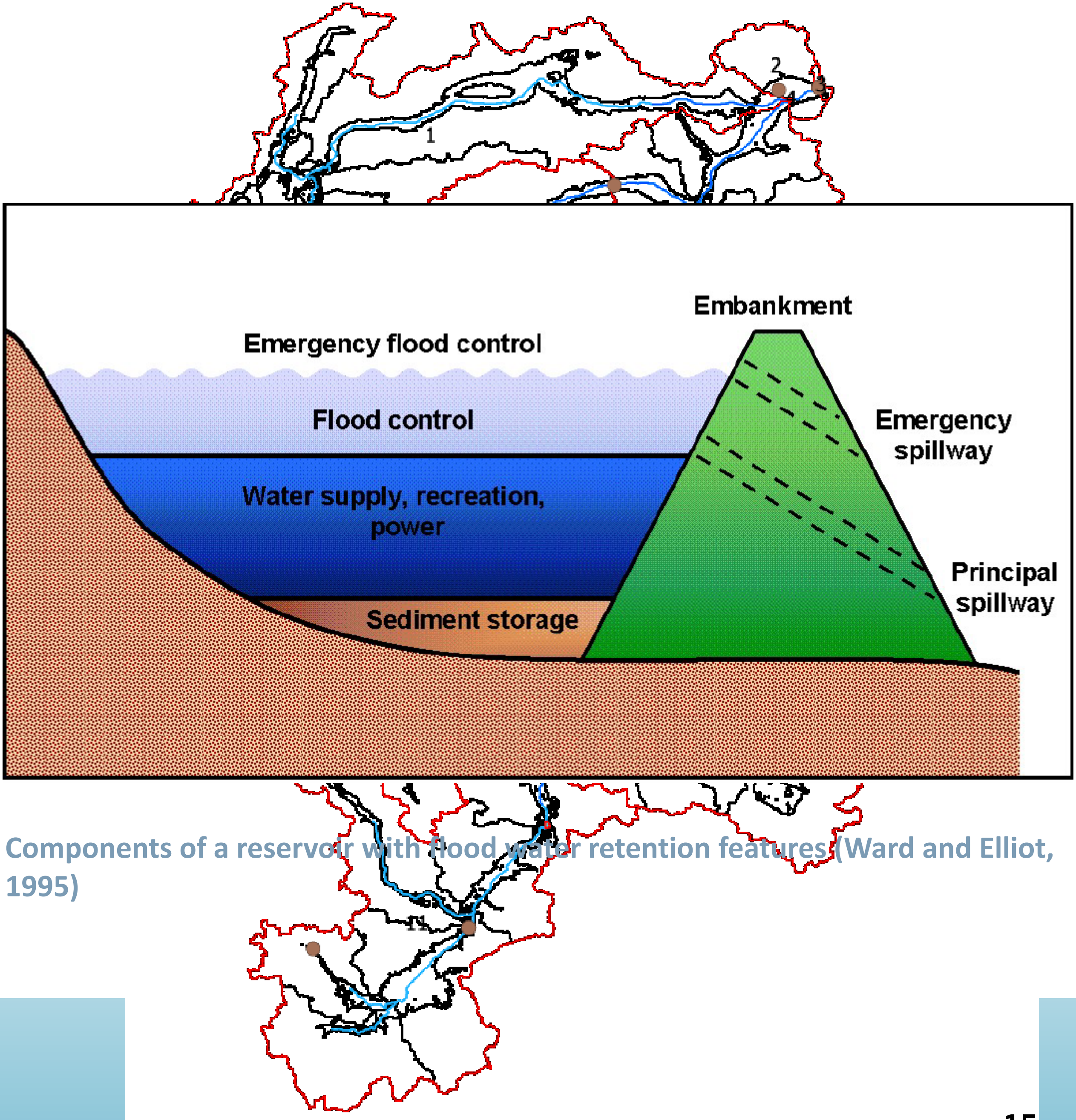
TILE DRAINAGE

- Like GW, Tile flow mostly contribute to the baseflow portion of the stream hydrograph.



LAKES? RESERVOIRS?

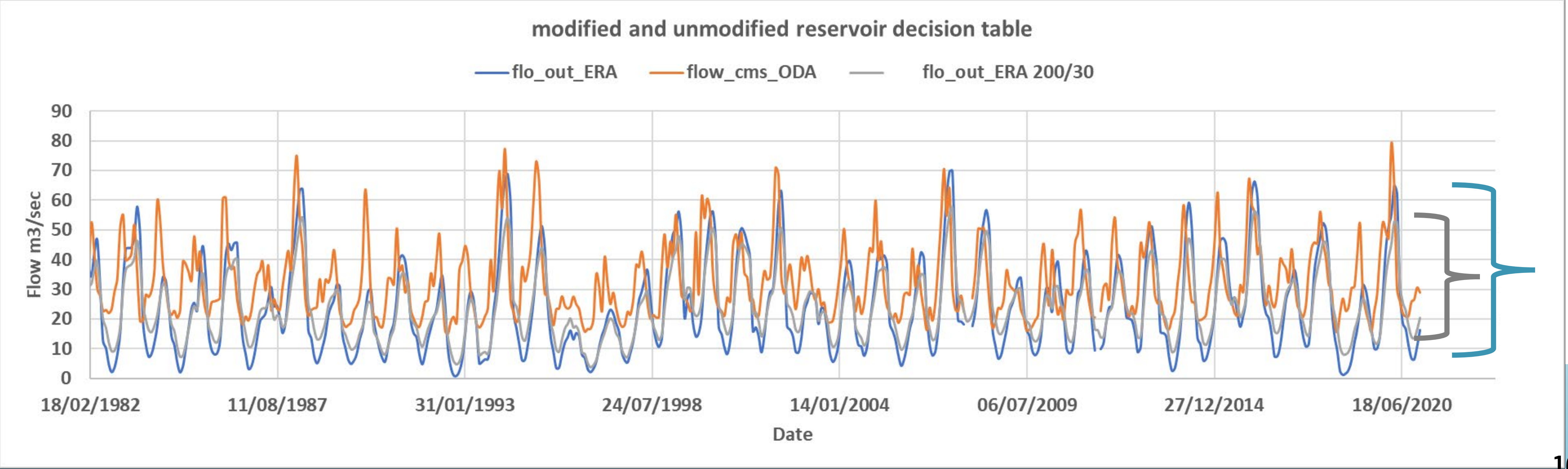
- We have 22 lakes in the catchment as reservoir object in swat+.
- Swat+ defines lakes as a simple reservoir with Ps and Es amount.
- Difficult to develop universal reservoir operation routines or models for all possible cases.
- Need to understand the effect of these lakes have on the retention of water.
- we continue to work on reservoir **Outflow and storage relationship.**



Components of a reservoir with flood water retention features (Ward and Elliot, 1995)

DECISION TABLE

- Adapt the reservoir decision table to control the outflow.
- In the **target release approach**, the principal spillway volume corresponds to the storage with a maximum flood control capacity, while the emergency spillway volume corresponds to the storage with no flood control capacity.
- Experimenting with **principal and emergency volumes**.
- Yielded an increase in baseflow, and much better hydrographs. Further work on these areas is ongoing.




work in
progress
0%
100%

THANK YOU FOR YOUR ATTENTION