Department of Hydrology and Water Resources Management

Institute for Natural Resource Conservation

Exploring the capabilities of SWAT+ in a rural lowland catchment in the North of Germany

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Motivation

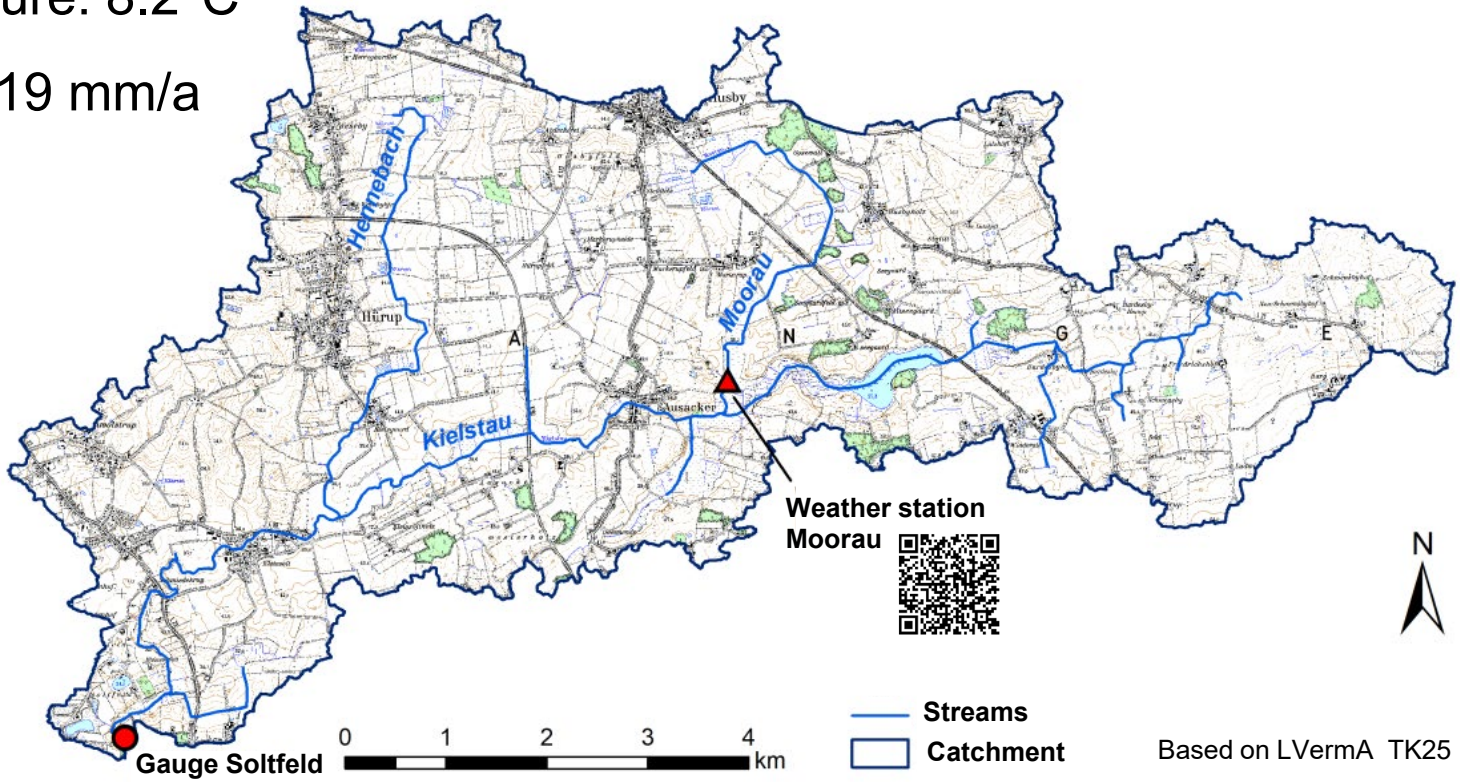
- Model testing for:
  - Small 50 km² catchment
  - Lowland catchment: groundwater processes

Is SWAT+ able to represent the Kielstau catchment?

Similarities and differences as compared to the old SWAT?

Study area: Kielstau catchment

- UNESCO demonstration site for ecohydrology since 2010
- Subbasin of the Treene, Area: 50 km²
- Agriculture dominates: ~64% cropland, ~20% pasture
- Mean temperature: 8.2°C
- Precipitation: 919 mm/a



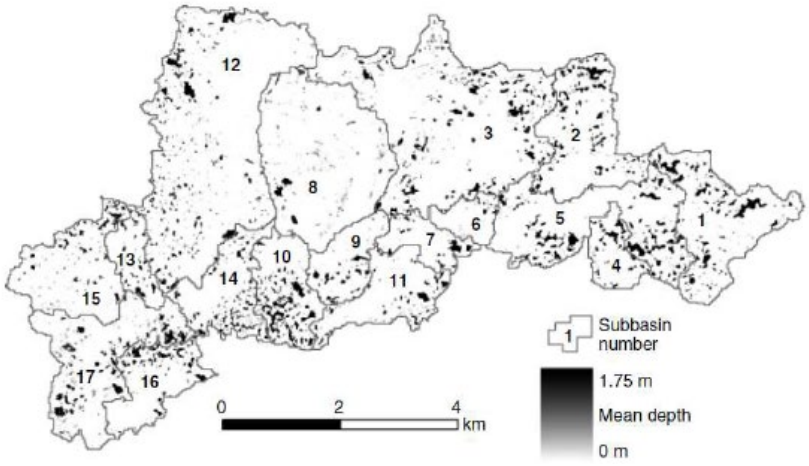
Kielstau catchment

Modelling with the eco-hydrological model SWAT

- Water fluxes and water balance components
- Water quality (nitrate, phosphate)
- Pesticides

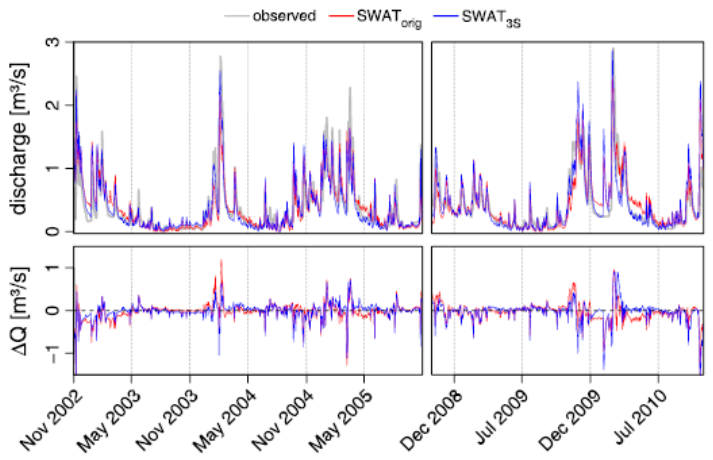
Arnold et al. (1998)

Model - representation of the Kielstau



Kiesel et al. (2010)

Model validation



Pfannerstill et al. (2014)

Materials and Methods

SWAT3S (Pfannerstill et al. 2014) vs. SWAT+ (Bieger et al. 2017)

SWAT2012 Rev. 582 with fast and slow shallow aquifer

Better representation of groundwater processes in lowland catchments

Developed and tested in the Kielstau Catchment

SWAT+ is the latest and completely restructured version of SWAT

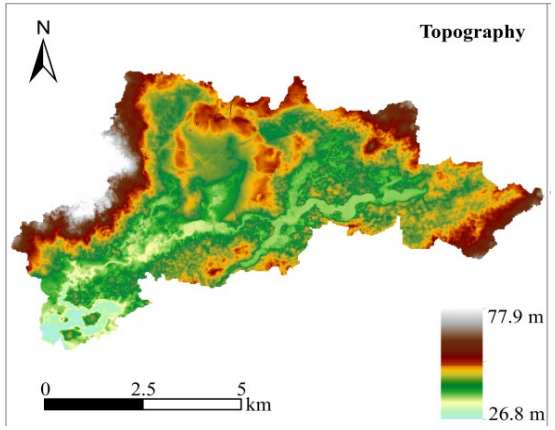
Two configurations:

1) Similar to SWAT: HRU yields are summed up at the subbasin level
   a) 1 aquifer
      → SWAT+ 1AQU
   b) 2 aquifers (fast and slow)
      → SWAT+ 2AQU
2) Landscape version: Runoff is routed across the landscape before it reaches the stream → SWAT+ LSU

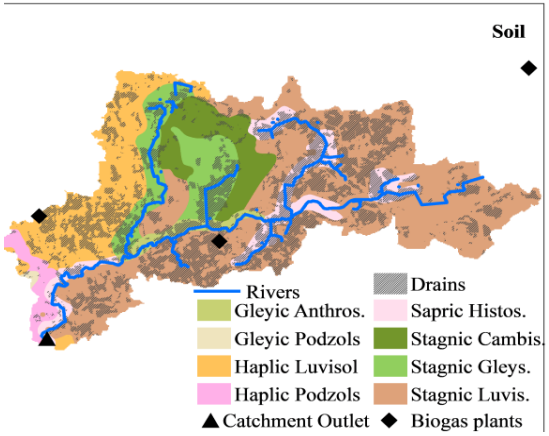
Materials and Methods

Same inputs for both models:

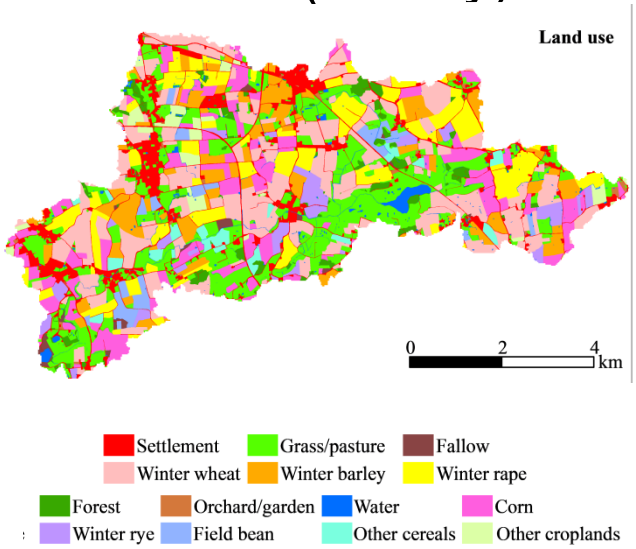
DEM (LVA, 2004)



Soil map (BGR, 1999)



Land use (survey)



Weather data:

Since 2000, from one weather station outside the catchment, since 2010 precipitation measured within the catchment

Materials and Methods

Simulation periods

- Calibration: 1 Oct. 2013 - 31 Dec. 2016
- Validation: 1 Oct. 2010 - 30 Sept. 2013

Calibration technique for SWAT3S

- Latin Hypercube Sampling to derive 5000 parameter sets (R package FME, Pfannerstill et al. 2014)
- Best parameter set selected for the calibration period based on
  - Representation of groundwater flow (> 60 mm/a)
  - Best Kling-Gupta efficiency

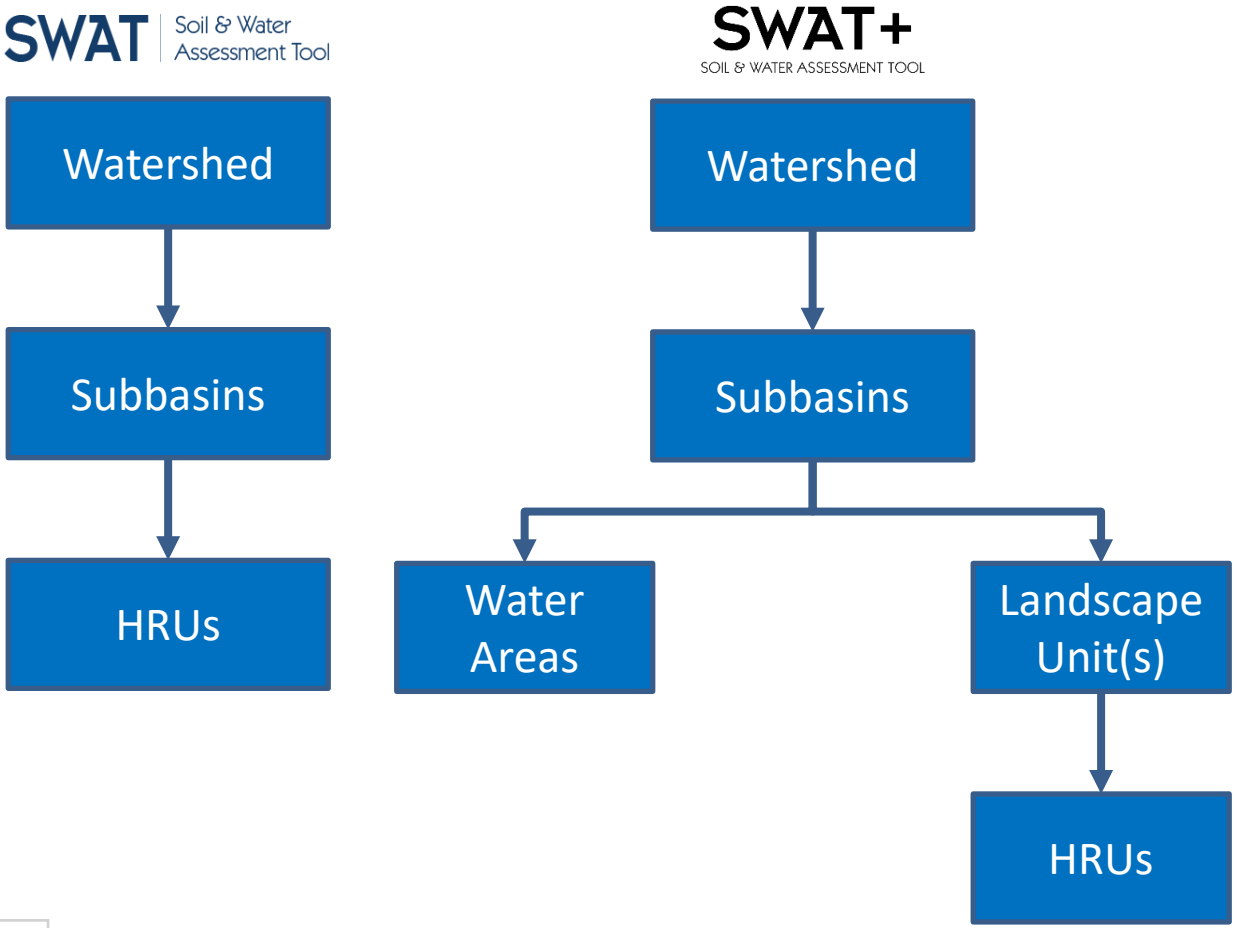
Materials and Methods

Parameter ranges and final values SWAT3S

Parameter	min	max	change method	final value SWAT3S
SMTMP	-2.5	2.5	replace	1.03
CN2	-10	10	add	4.57
SURLAG	0.2	1.2	replace	0.20
SOL_AWC	-0.07	0.1	add	0.03
ESCO	0.7	1.0	replace	0.71
EPCO	0.7	1.0	replace	0.82
GW_DELAY	1	25	replace	10.82
RCHRG_DP	0.2	0.8	replace	0.26
ALPHA_BF	0.2	1.0	replace	0.48
ALPHA_BF2	0.001	0.04	replace	0.017
GDRAIN	0.5	1.5	relative change	1.15
TDRAIN	0.62	1.50	relative change	0.80
DDRAIN	0.78	1.24	relative change	0.90
SDRAIN	15000	45000	replace	43839
DRAINCO	5	20	replace	14
DEPIMP	1230	6000	replace	5985

Materials and Methods

Differences in model setup



ArcSWAT
vs QSWAT+

- Watershed
- Subbasins
- Stream network

Materials and Methods

SWAT+ LSU Setup:

- Runoff generated in uplands
  - partly sent directly to the stream
  - partly routed to the corresponding floodplain
  - Fractions depend on ratio of upland and floodplain areas

Basic manual calibration of SWAT+ 1AQU and SWAT+ 2AQU

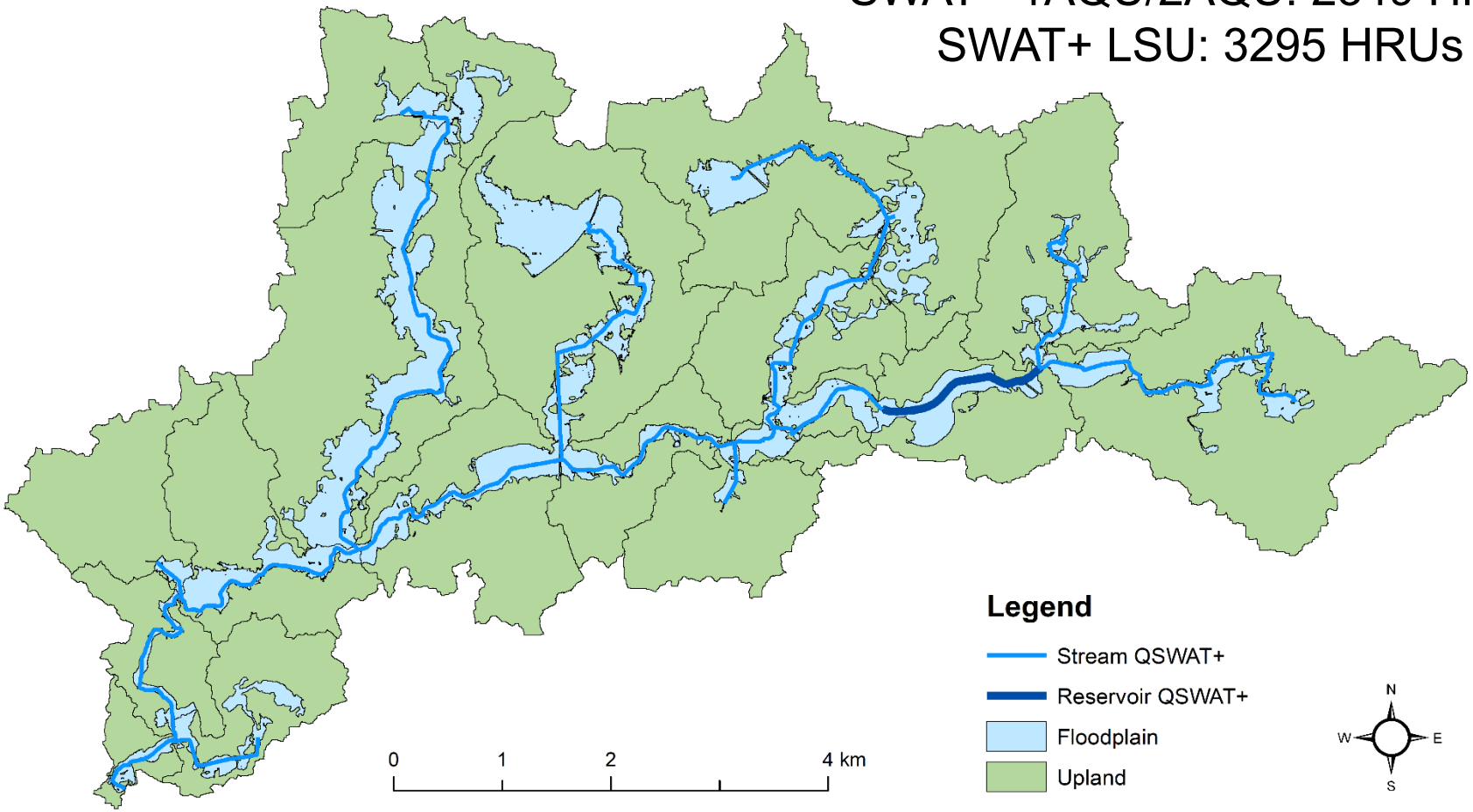
No calibration of SWAT+ LSU

Comparison of model output based on NSE, KGE, PBIAS, Hydrographs, Flow Duration Curves, RSR for FDC segments

Results

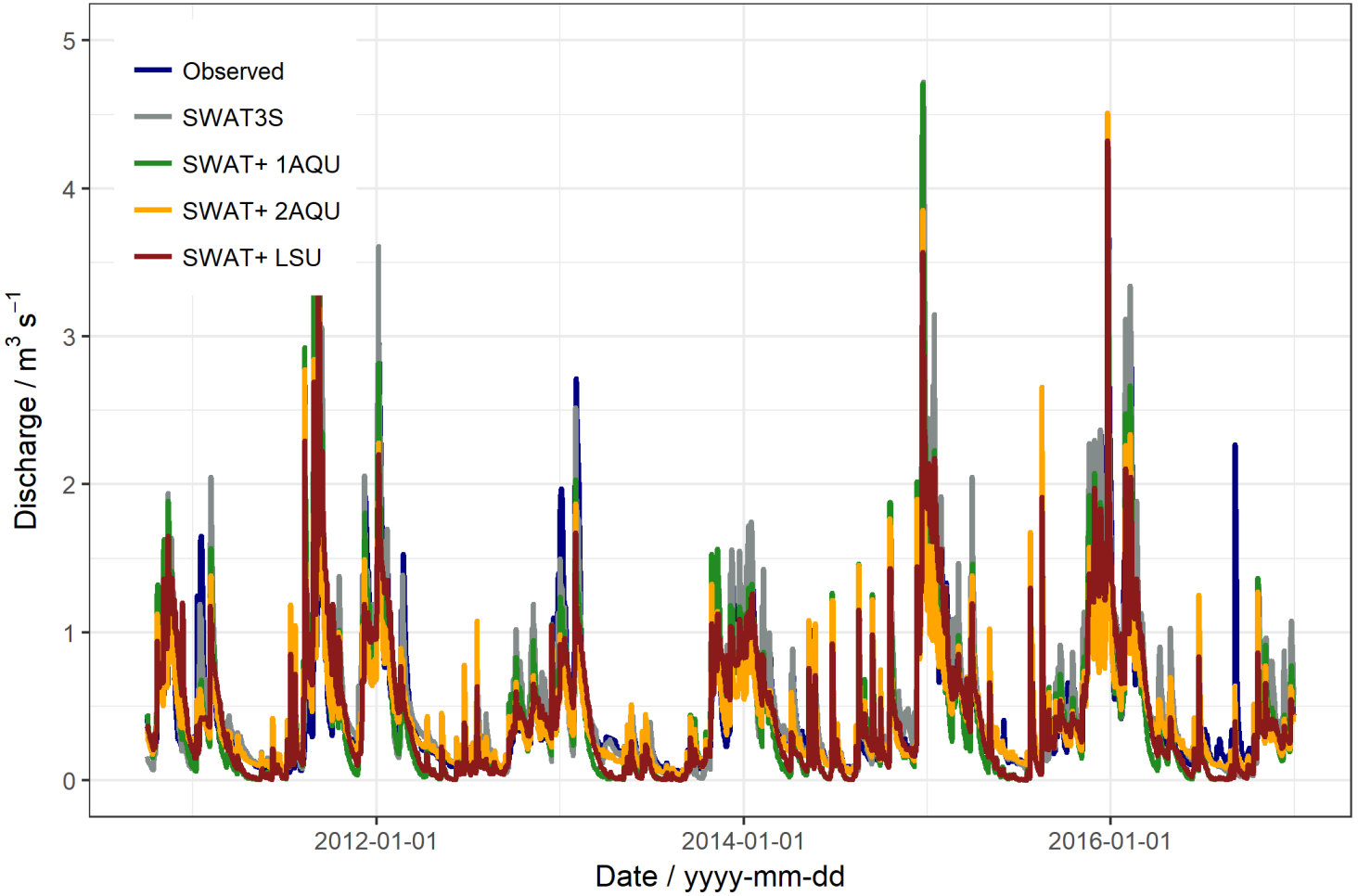
Watershed delineation

SWAT3S: 2622 HRUs
SWAT+ 1AQU/2AQU: 2349 HRUs
SWAT+ LSU: 3295 HRUs



Results

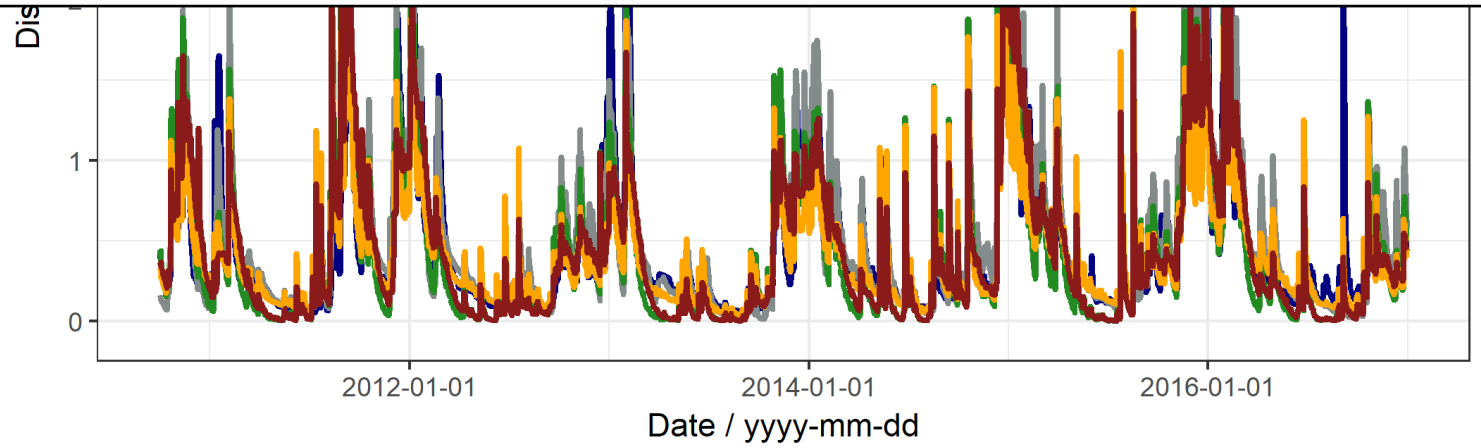
Hydrograph comparison - calibration and validation periods



Results

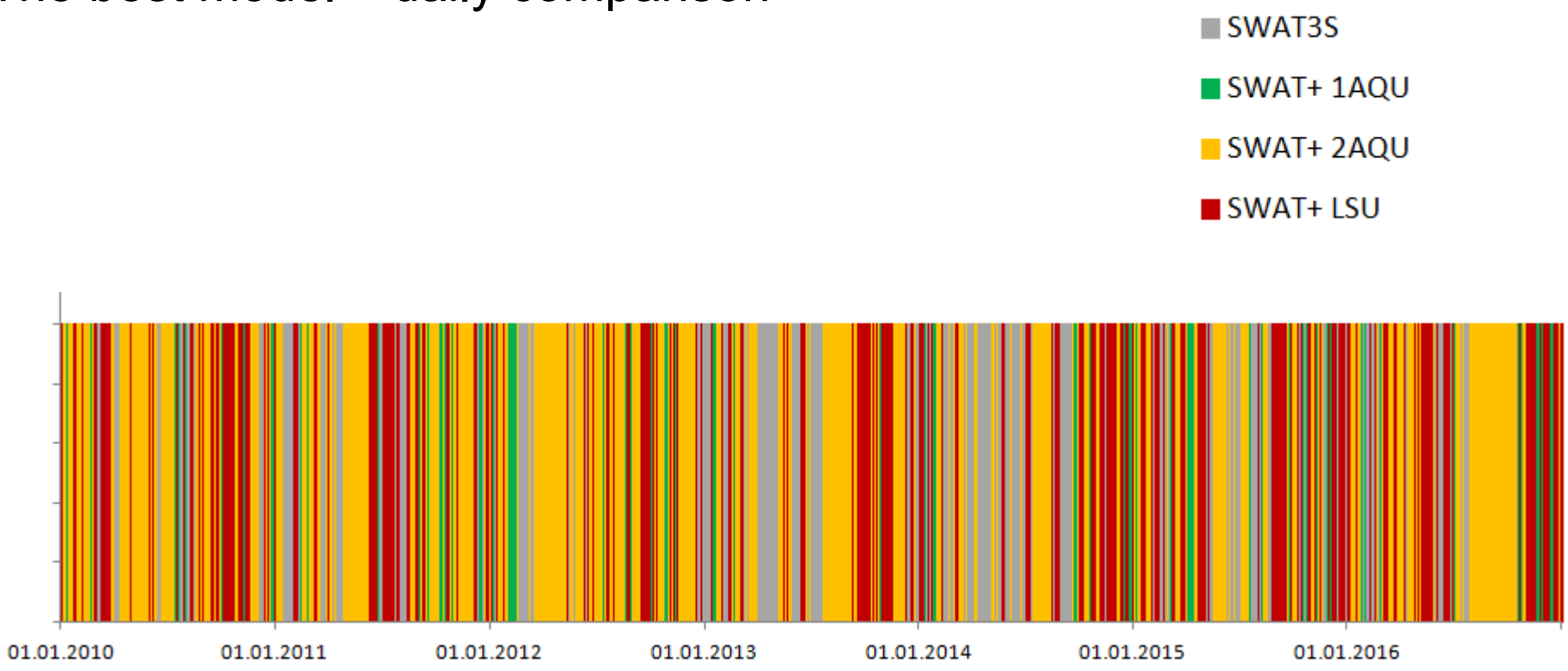
Hydrograph comparison - calibration and validation periods

		SWAT3S	SWAT+ 1AQU	SWAT+ 2AQU	SWAT+ LSU
Cal	NSE	0.81	0.74	0.70	0.76
	KGE	0.81	0.84	0.71	0.83
	PBIAS	12.2	-10.1	-11.3	-9.9
Val	NSE	0.71	0.61	0.63	0.60
	KGE	0.78	0.79	0.71	0.78
	PBIAS	12.9	-9.4	-8.5	-8.4



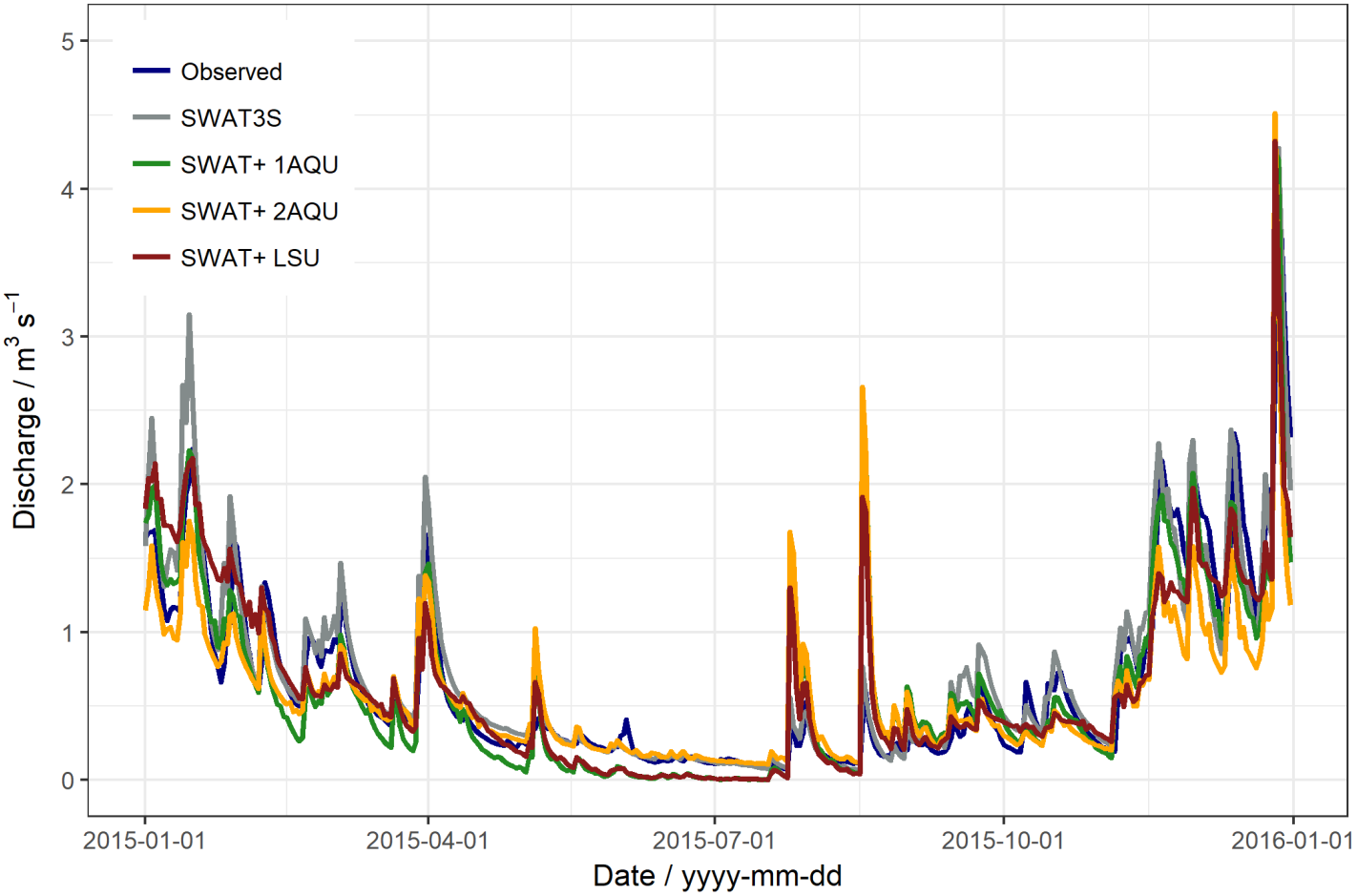
Results

The best model – daily comparison



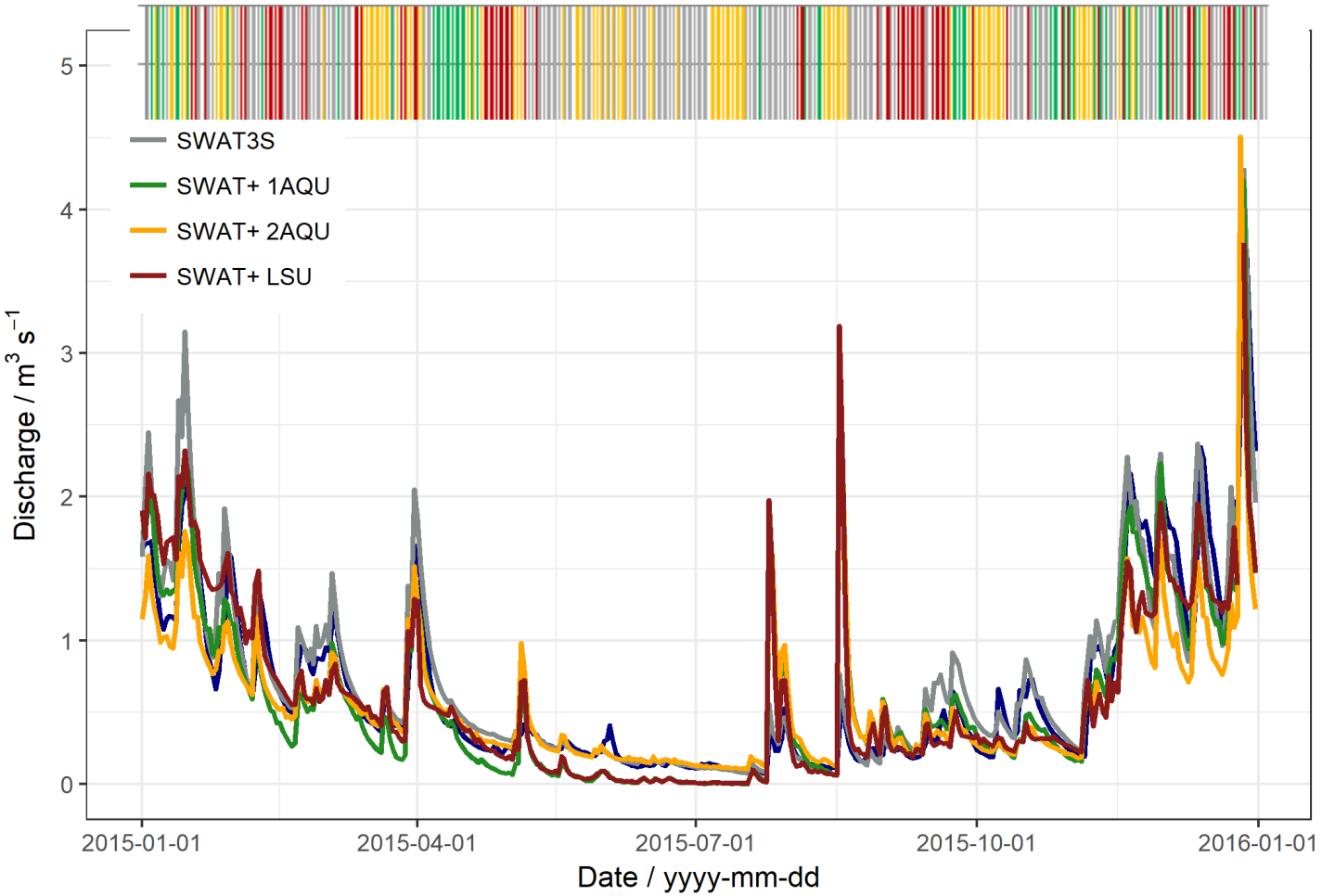
Results

Hydrograph comparison – year 2015



Results

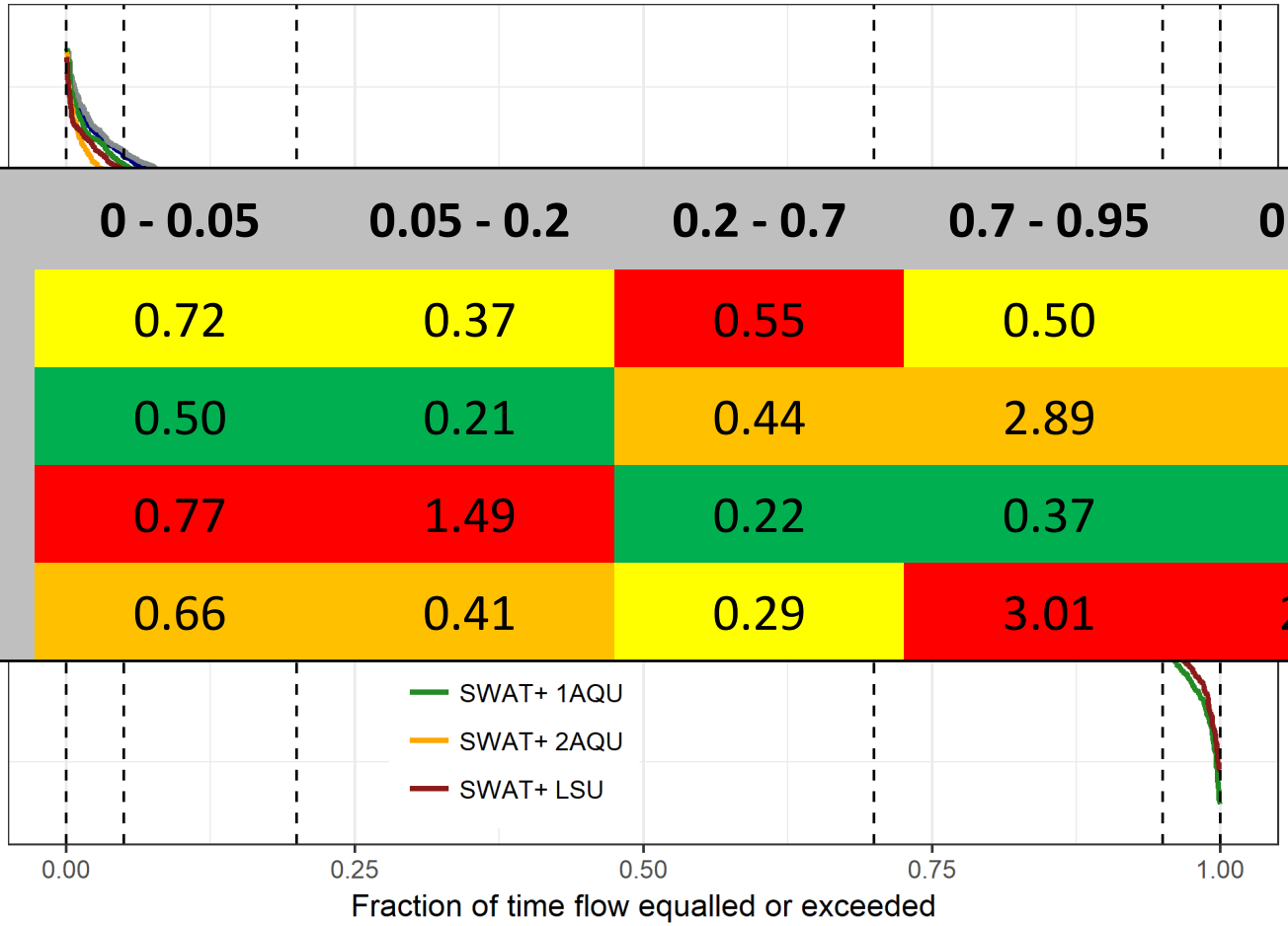
The best model – daily comparison



Results

Flow duration curves

	0 - 0.05	0.05 - 0.2	0.2 - 0.7	0.7 - 0.95	0.95 - 1
SWAT3S	0.72	0.37	0.55	0.50	2.27
SWAT+ 1AQU	0.50	0.21	0.44	2.89	4.81
SWAT+ 2AQU	0.77	1.49	0.22	0.37	0.57
SWAT+ LSU	0.66	0.41	0.29	3.01	26.89



Conclusions

- SWAT+ represents the Kielstau well:
  - SWAT2012 was more successful – fully calibrated
  - SWAT+ relatively successful – first try, manually calibrated
- SWAT+ LSU did not perform good for low flows but comparetively good for mid-high flows - without calibration
- 2nd groundwater layer is important!
- Overall a good experience, but the transfer of the model data base (for your own catchment) could be demanding
- Steps ahead: Automatic calibration for SWAT+, add a 2nd groundwater layer to SWAT+ LSU


Thank you very much!
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