Department of Hydrology and Water Resources Management

Institute for Natural Resource Conservation

Modeling lowland catchment hydrology: A comparison of model versions

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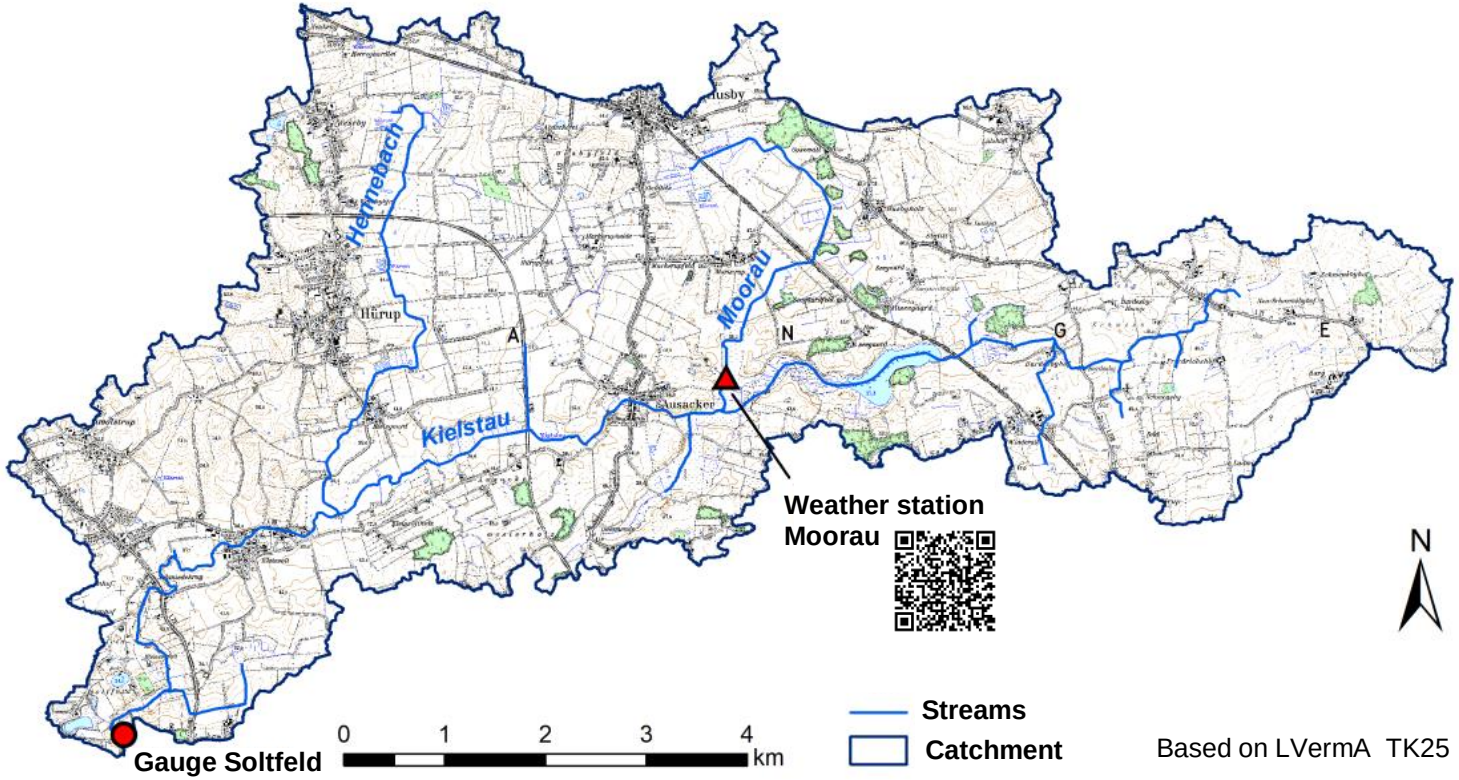
Study area: Lowland catchment Kielstau, Northern Germany

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

- Previous Kielstau SWAT models
  - Kiesel et al. (2010)
  - Pfannerstill et al. (2014)



Materials and Methods

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

SWAT2012 Rev. 582 (Arnold et al. 1998) with fast and slow shallow aquifer

Better representation of groundwater processes in lowland catchments

Developed and tested in the Kielstau Catchment

Calibration: Latin Hypercube Sampling to derive 5000 parameter sets, final parameter set selected based on best Kling-Gupta efficiency

SWAT+ is the latest and completely restructured version of SWAT

Two configurations:

1) SWAT+ HRU, similar to SWAT: HRU yields are summed up at the subbasin level,
2) SWAT+ LSU, landscape version: Runoff is routed across the landscape before it reaches the stream

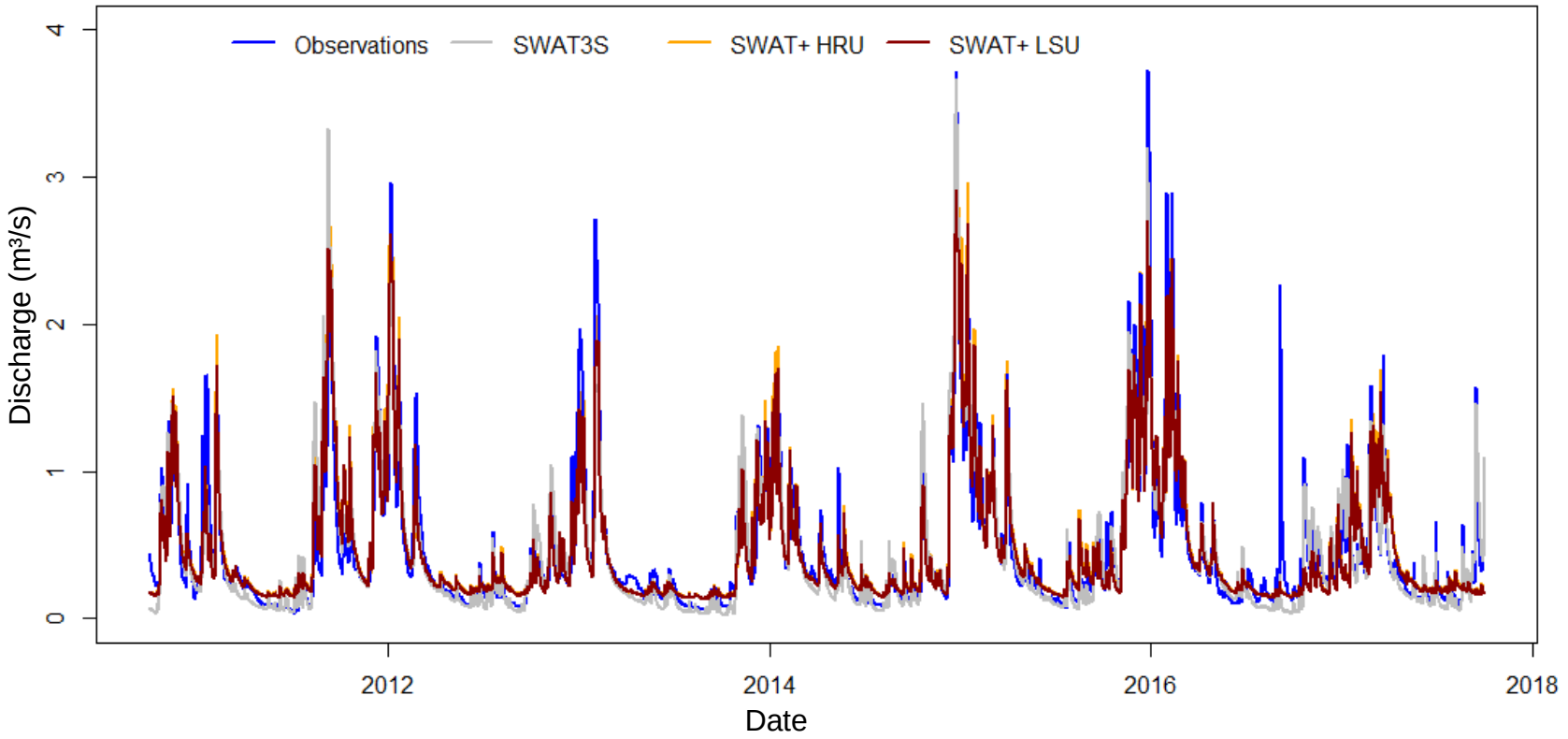
Calibration: - SWAT+ HRU: Manual calibration

- SWAT+ LSU: No specific calibration, same parameters used as in SWAT+ HRU

Same input data for both models: DEM, land use, soil, weather, point sources data, management, tile drainage

Calibration period: 1 Oct. 2010 - 30 Sept. 2014, Validation period: 1 Oct. 2014 - 30 Sept. 2017

Results: Model Performance

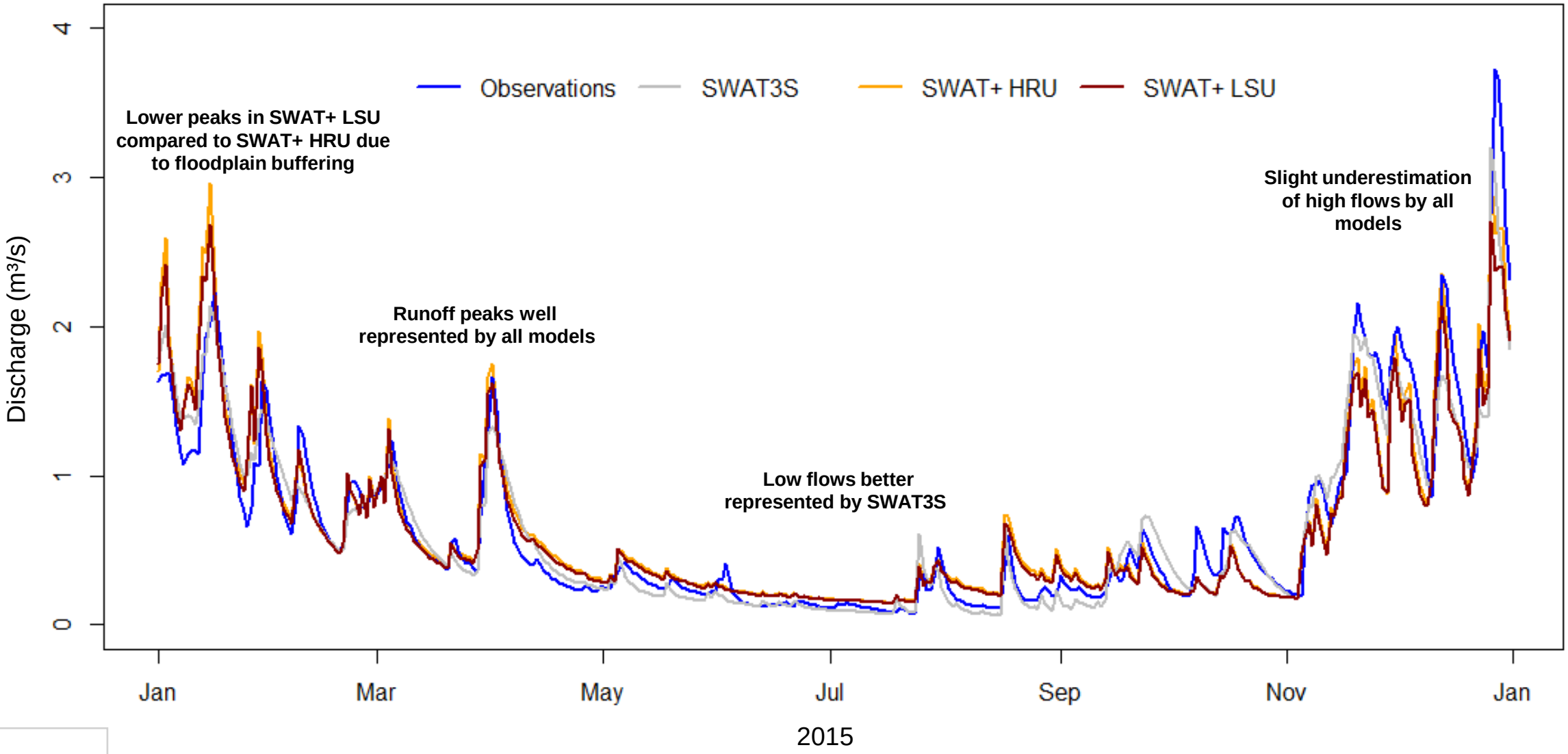


		SWAT 3S	SWAT + HRU	SWAT + LSU
Calibration	NSE	0.85	0.81	0.82
	KGE	0.89	0.88	0.85
	PBIAS	5.9	-3.3	0.9
Validation	NSE	0.89	0.80	0.80
	KGE	0.92	0.88	0.83
	PBIAS	2.1	-0.1	4.0

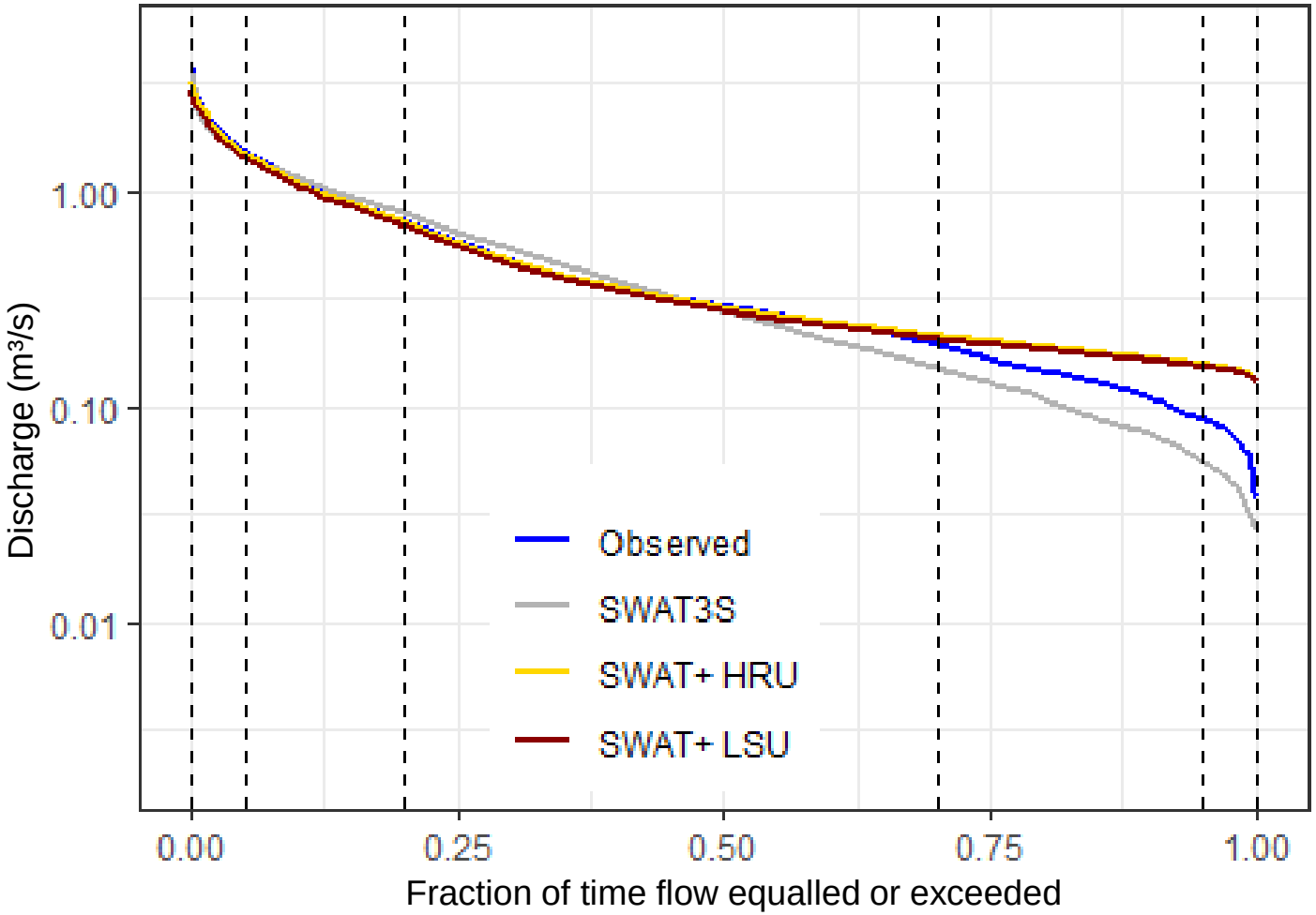
Differences in model performance are small, but:

- SWAT3S performs slightly better with regard to NSE and KGE
- SWAT+ simulations have a slightly lower PBIAS value
- Streamflow predictions by the two SWAT+ models are very similar

Results: Hydrograph Comparison – Year 2015



Results: Flow Duration Curves



RSR	0 - 0.05	0.05 - 0.2	0.2 - 0.7	0.7 - 0.95	0.95 - 1
SWAT 3S	0.38	0.19	0.35	1.16	2.50
SWAT+ HRU	0.11	0.30	0.13	2.17	7.97
SWAT+ LSU	0.34	0.48	0.15	2.01	7.71

- Best performing model differs for high, mid, and low flows
- SWAT3S underestimates low flows
- SWAT+ overestimates low flows

Conclusions

- All model versions are able to represent lowland hydrology. This is possibly due to the fact that all models accounted for key characteristics of lowland hydrology, like tile drainage and fast and slow groundwater flows.
- Effect of full calibration is clearly visible:
  - SWAT3S was more successful – fully calibrated, slightly better adapted
  - SWAT+ relatively successful – manually calibrated
- Potential of the SWAT+ LSU model:
  - Performance of SWAT+ LSU is similar to SWAT+ HRU without any further calibration.
  - Studies in the US have indicated that distinguishing upland areas and floodplains as done in SWAT+ LSU leads to an improved representation of the saturation status of these two basic landscape units, while impacts on streamflow were limited.
  - Hence, even though performance at the catchment outlet was similar for all models, hydrologic processes within the catchment may be better represented by SWAT+ LSU.
- Future work:
  - Full calibration of SWAT+, especially the LSU setup, to further improve the representation of low flows.
  - Comparison of the representaton of water balance components by the models in space and time.

***References**:*

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