How parameter value identification is impacted by the selection of performance criteria – A SWAT study in four contrasting catchments in Germany

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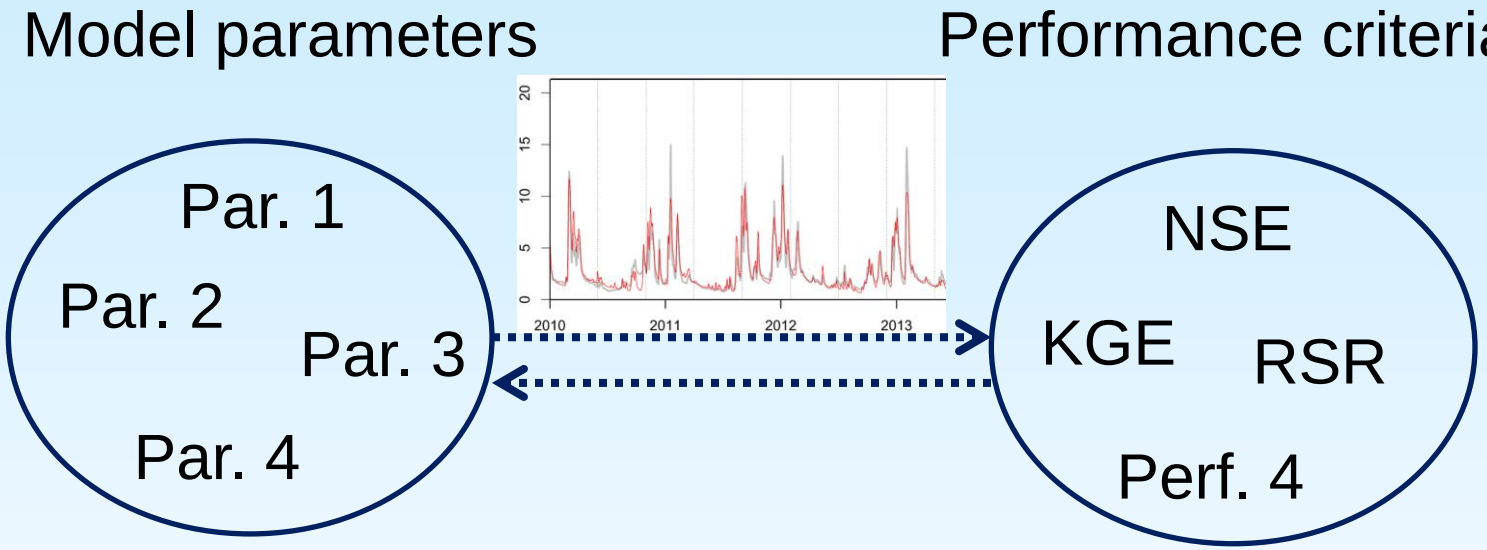
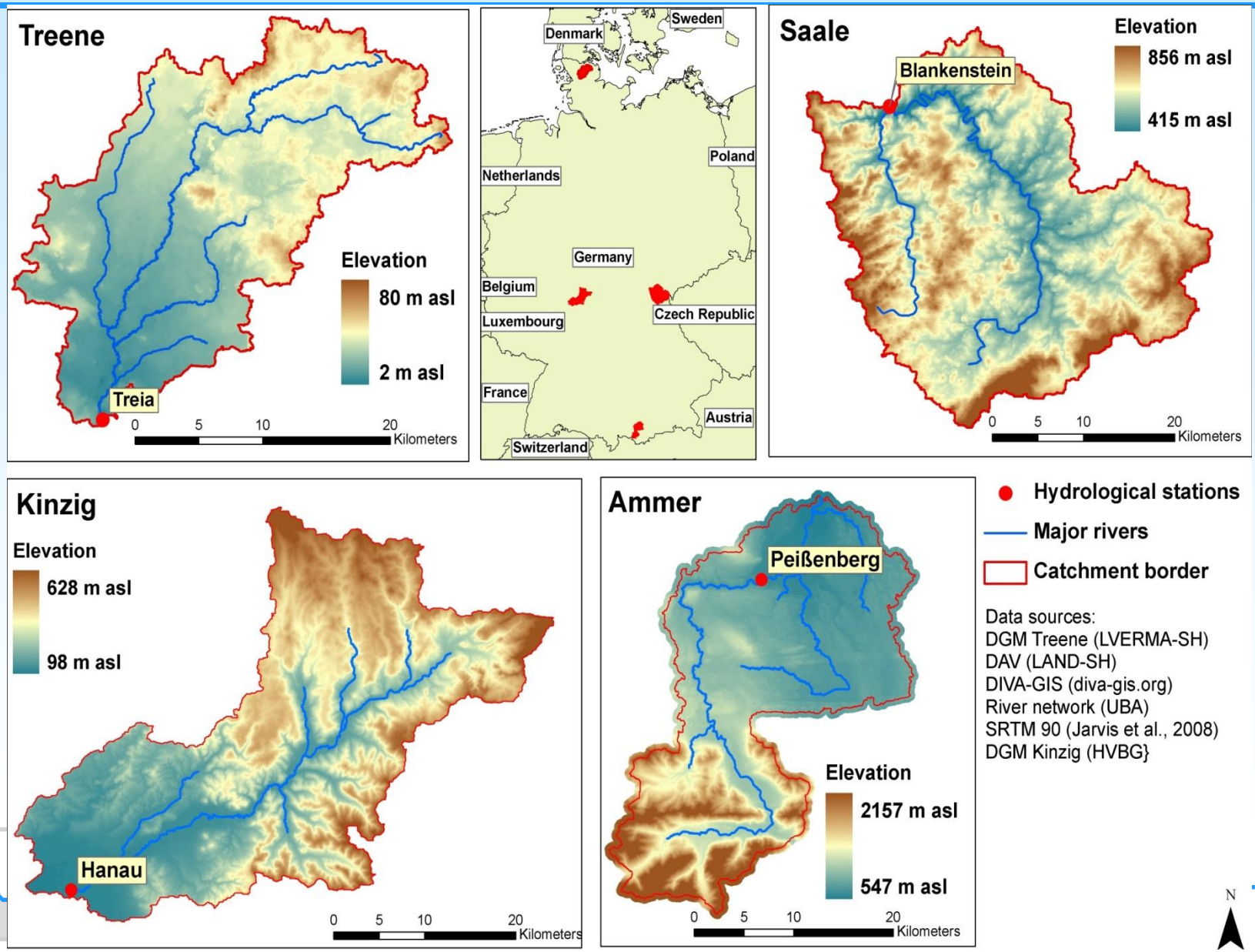
Multiple performance criteria to calibrate multiple model parameters

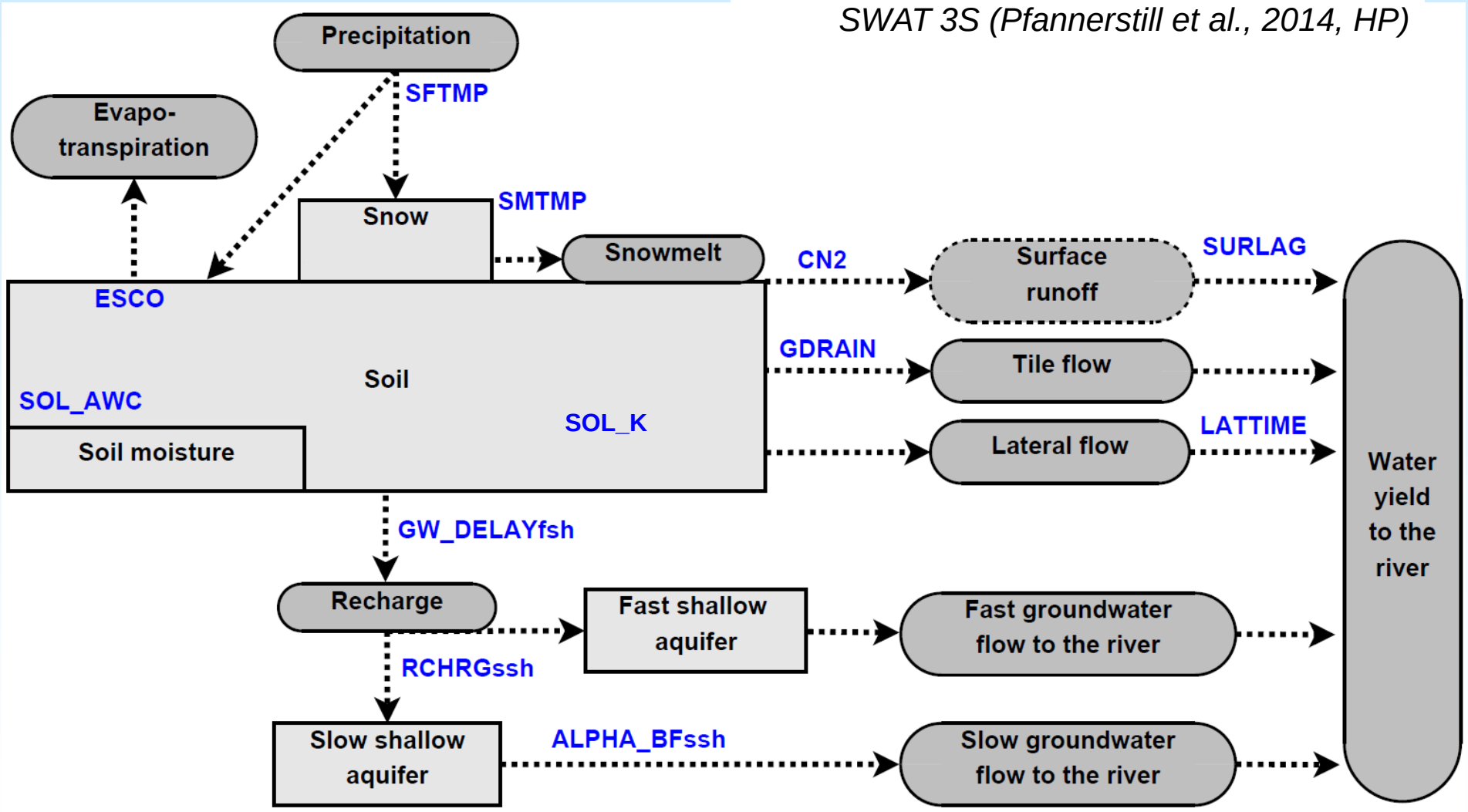


- Performance criteria are focused on different parts of the hydrograph
- Some parameter values impact different parts of hydrograph
- Selection of performance criteria impact identification of optimal parameter values

Four catchments



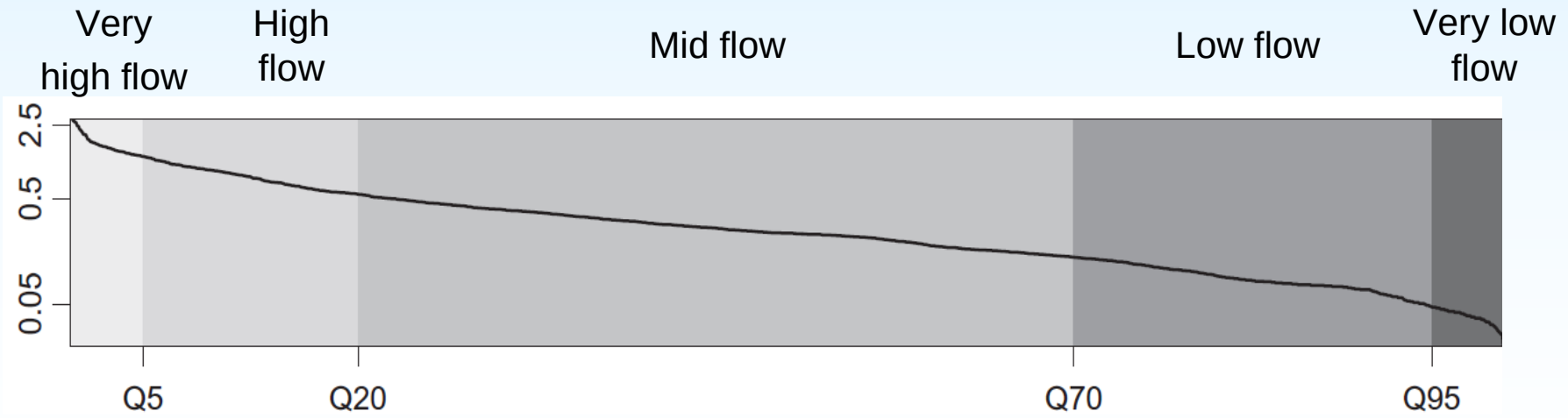
SWAT3S model version



Modified from Guse et al. (2014, HP; 2016, WRR)

Selection of performance criteria

- Multiple and complementary performance criteria to consider different aspects of hydrograph:
- NSE
- KGE + its components: KGE_alpha (variability), KGE_beta (bias), KGE_r (correlation)
- RSR for 5 flow duration curve segments:



Pfannestill et al. (2014, JH)

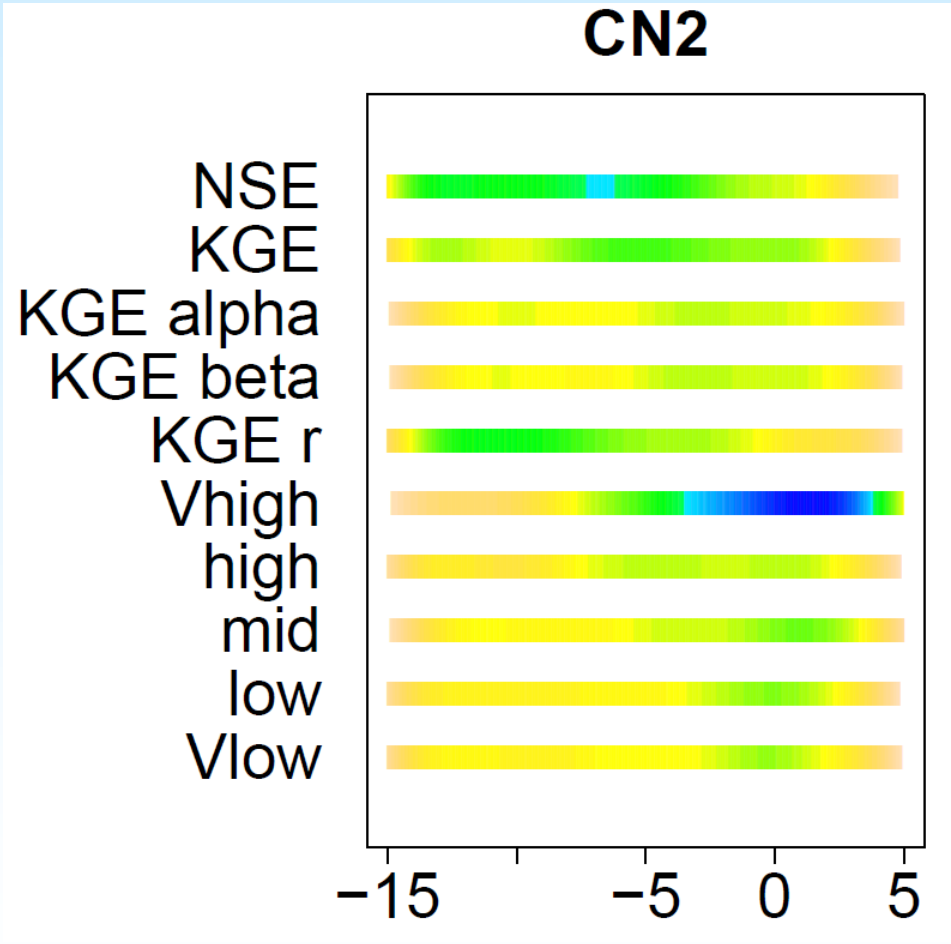
Methodological approach

- Latin-hypercube sampling with identical parameter sets in all catchments
- 2000 model simulations in each catchment (**LHinitial**)
- Selection 500 best model simulations separately for each performance criteria
- Comparison of parameter value distribution in subsets

- Refinement of parameter ranges based on all performance criteria
- 2000 model simulations with constrained parameter ranges (**LHconstrain**)
- Comparison of LHinitial with LHconstrain

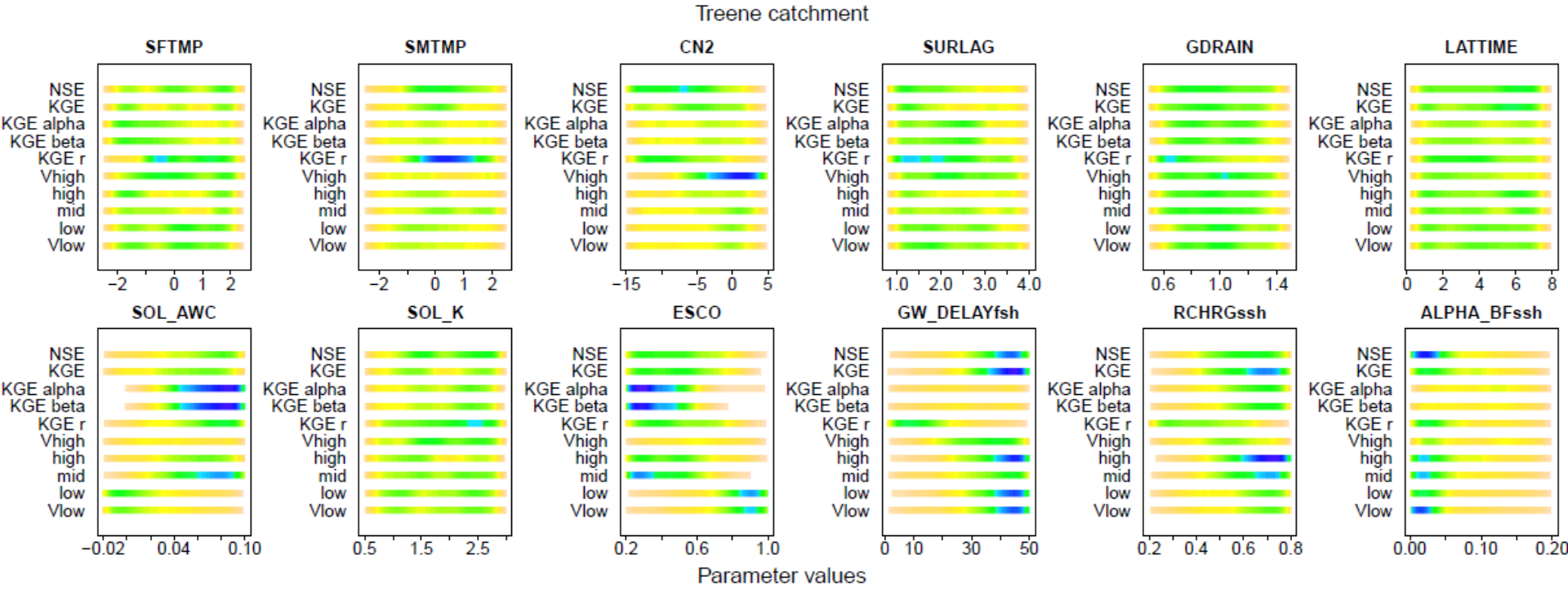
Parameter value identification (LHinitial)

- Analysis how often a parameter value is included in a subset of the best model runs
- Separately for each performance criterion
- Similar to histogram but as continuous coloured line.



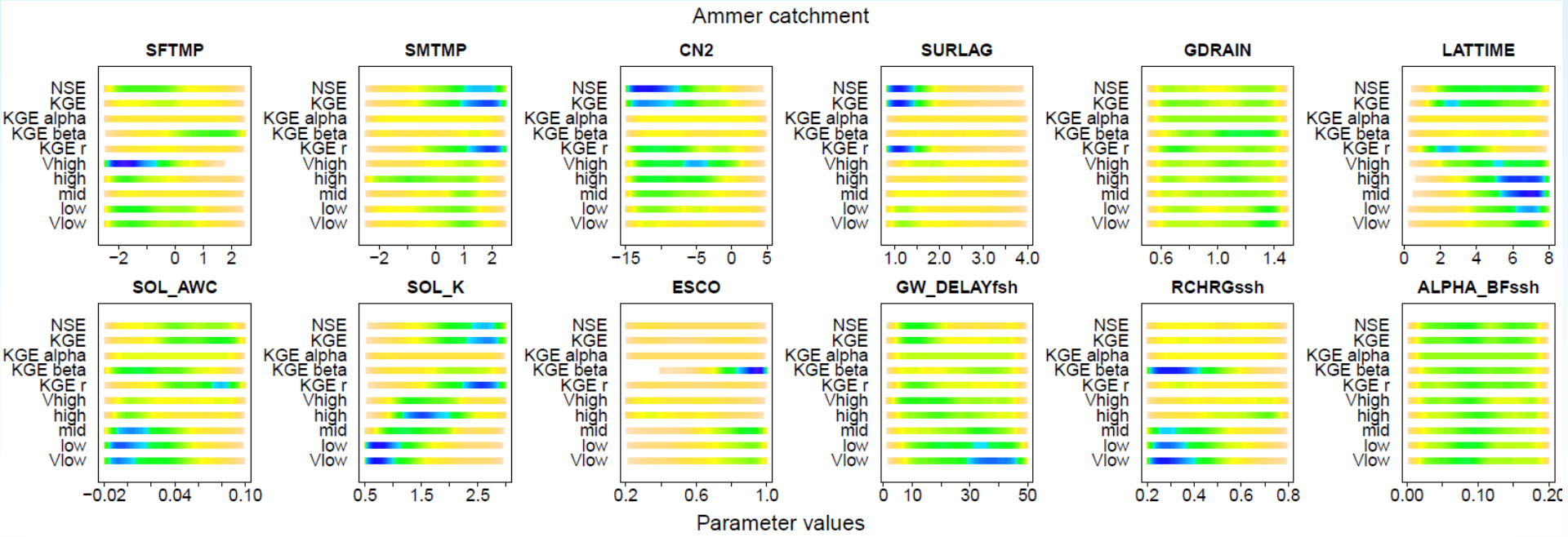
Parameter value identification (LHinitial) - Treene

- Clear parameter value identification: ALPHA_BFssh, GW_DELAYfsh
- Contrasting results: ESCO (medium vs. low flow)
- Unidentifiable: SFTMP, SURLAG, GDRAIN, LATTIME, SOL_K



Parameter value identification - Ammer

- Clear parameter value identification: SURLAG, LATTIME, RCHRGssh
- Contrasting results: SOL_K
- Unidentifiable: GDRAIN, ALPHA_BFssh



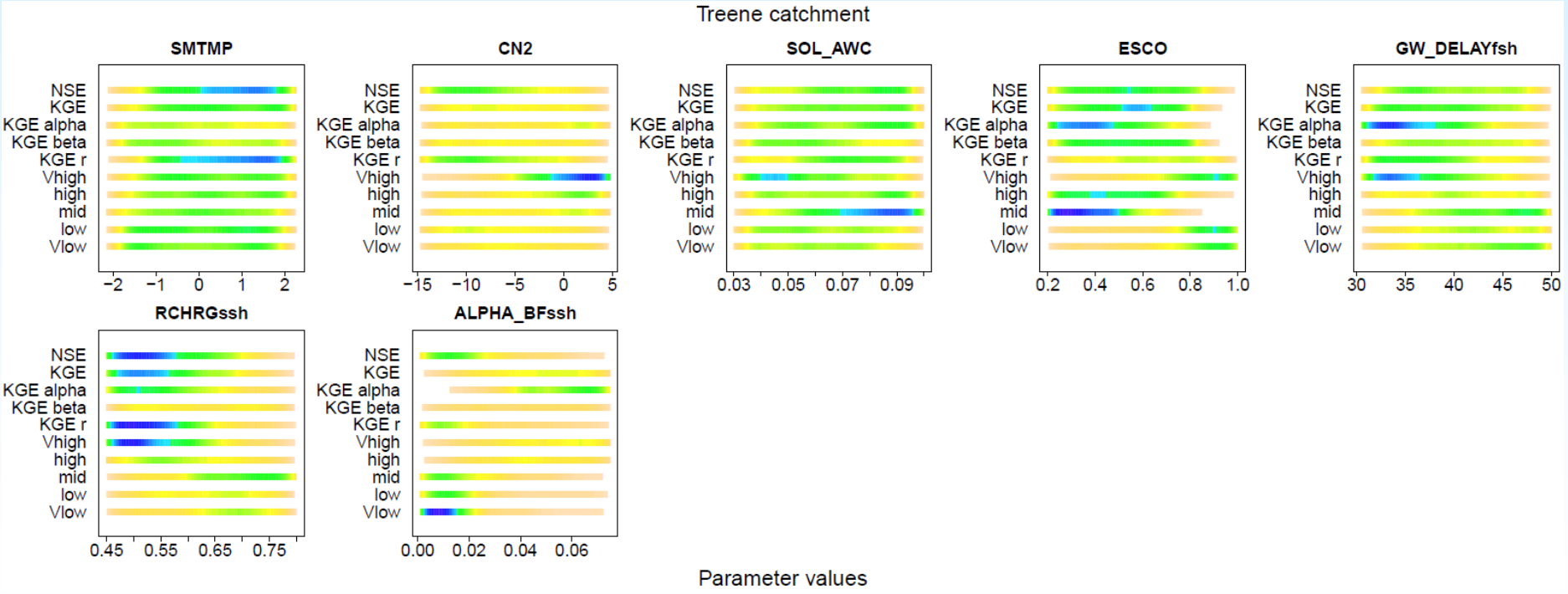
Parameter constraints (Treene)

- X = Parameter is not relevant and removed for the next simulations
- Value in % = Reduction of parameter range

Abbreviation	Treene	
	%	Range
SFTMP	x	
SMTMP	11	(-2.15, 2.28)
CN2	3	(-14.7, 4.8)
SURLAG	x	
LATTTIME	x	
GDRAIN	x	
SOL_AWC	42	(0.03, 0.1)
SOL_K	x	
ESCO	0	(0.2, 1)
GW_DELAYfsh	60	(30.5, 50)
RCHRGssh	42	(0.45, 0.8)
ALPHA_BFssh	63	(0.001, 0.075)

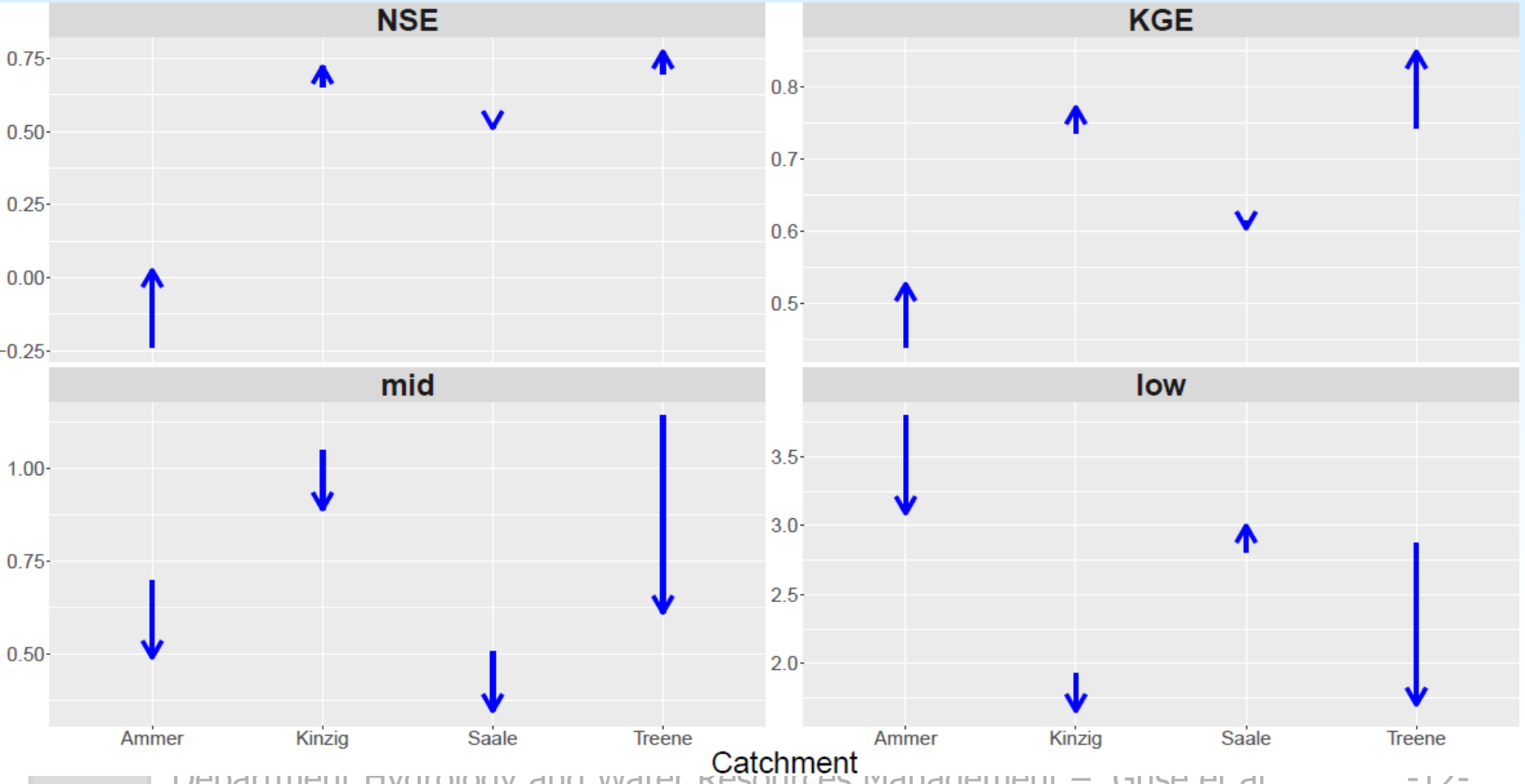
Parameter value identification with constrained parameter ranges - Treene

- All parameters are identifiable
- Refinement of parameter ranges removes unrealistic parameter sets



Model performance between LHinitial and LHfinal

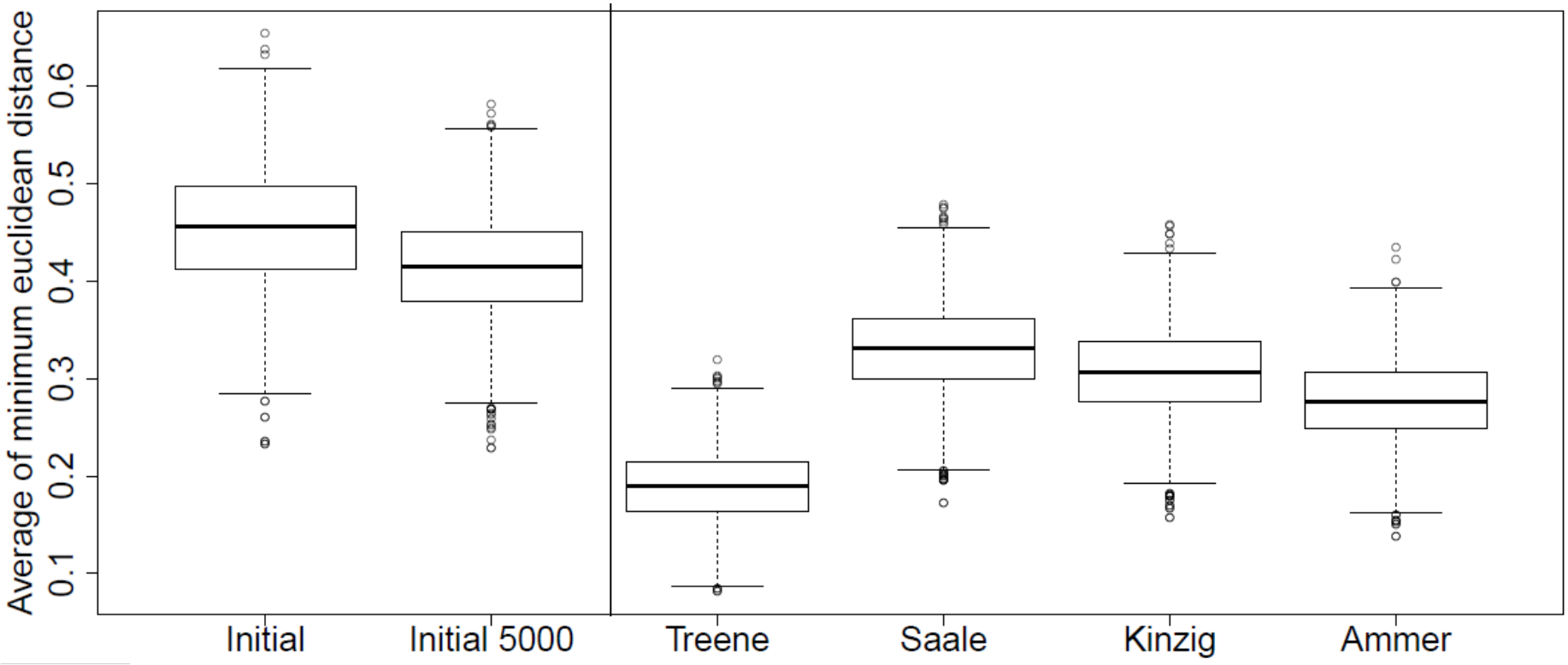
- Change in median values between LHinitial and LHfinal for selected performance criteria



Coverage of parameter space

- Euclidean distance between all parameter combinations
- Calculation of the minimum distance for each parameter set
- Presentation as boxplots

Reduction of parameter ranges leads to better coverage of parameter space compared to a larger number of model runs



Conclusion

- Parameter value identification benefit from using multiple performance criteria
- Contradictive results indicate that a parameter is required to reproduce different parts of the hydrograph accurately
- Refinement of parameter space improves model performance and leads to higher number of good model simulations
- It is more useful to reduce the parameter ranges as much as hydrologically meaningful instead of increasing the number of model simulations
- Unidentifiable parameters did not impact the chosen performance criteria (based on the hydrograph) but may be relevant for other processes

Thank you for your attention

References for further information

- Guse, B.; Reusser, D. E.; Fohrer, N. (2014): How to improve the representation of hydrological processes in SWAT for a lowland catchment - Temporal analysis of parameter sensitivity and model performance, Hydrol. Process., 28: 2651–2670
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- Pfannerstill, M.; Guse, B. and Fohrer, N. (2014). A multi-storage groundwater concept for the SWAT model to emphasize nonlinear groundwater dynamics in lowland catchments. Hydrol. Process., 28(22):5599-5612, doi:10.1002/hyp.10062.
- Pfannerstill, M.; Guse, B.; Fohrer, N. (2014): Smart low flow signature metrics for an improved overall performance evaluation of hydrological models, J. Hydrol, 510, 447-458, doi:10.1016/j.jhydrol.2013.12.044.