Diagnostic tools to understand hydrological processes in the SWAT model

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und Wasserwirtschaft

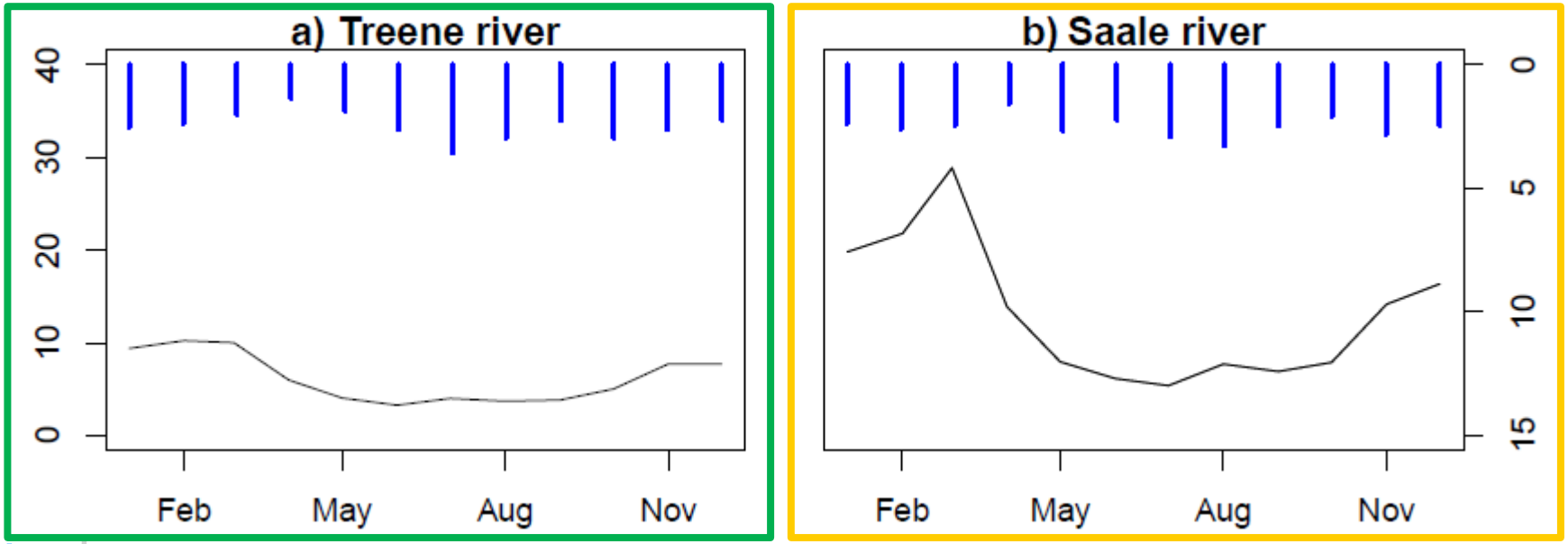
DFG

Processes in models and catchments

- Hydrological processes are controlled in the SWAT model with different parameters
- These parameters are adapted to the conditions in the study catchment
- To obtain realistic process representations, diagnostic model analyses are helpful to investigate the parameter and process dynamic

3 diagnostic tools for process understanding in SWAT

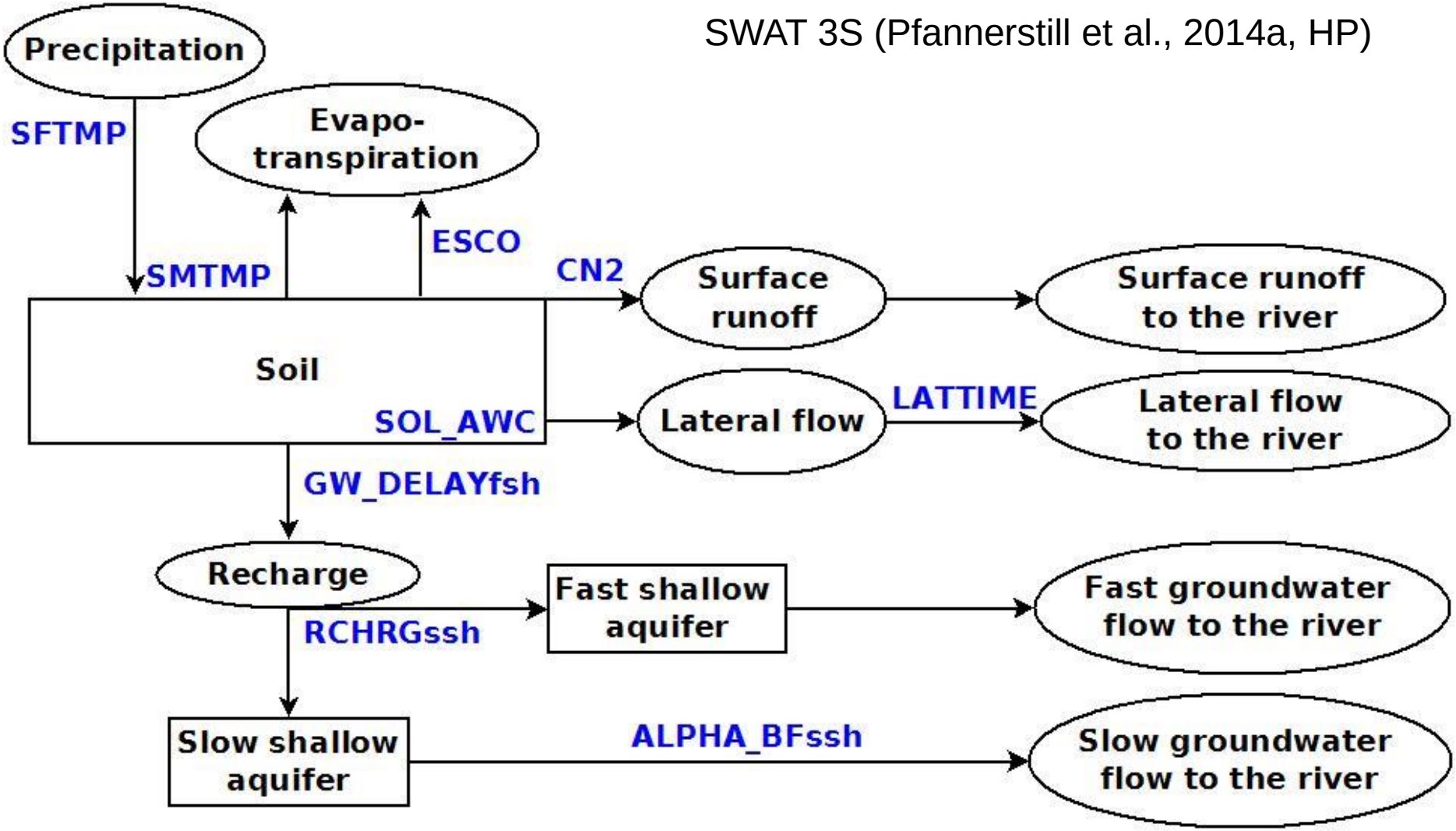
Study sites: Treene and Saale



Modified from Guse et al. (in prep. for HP)

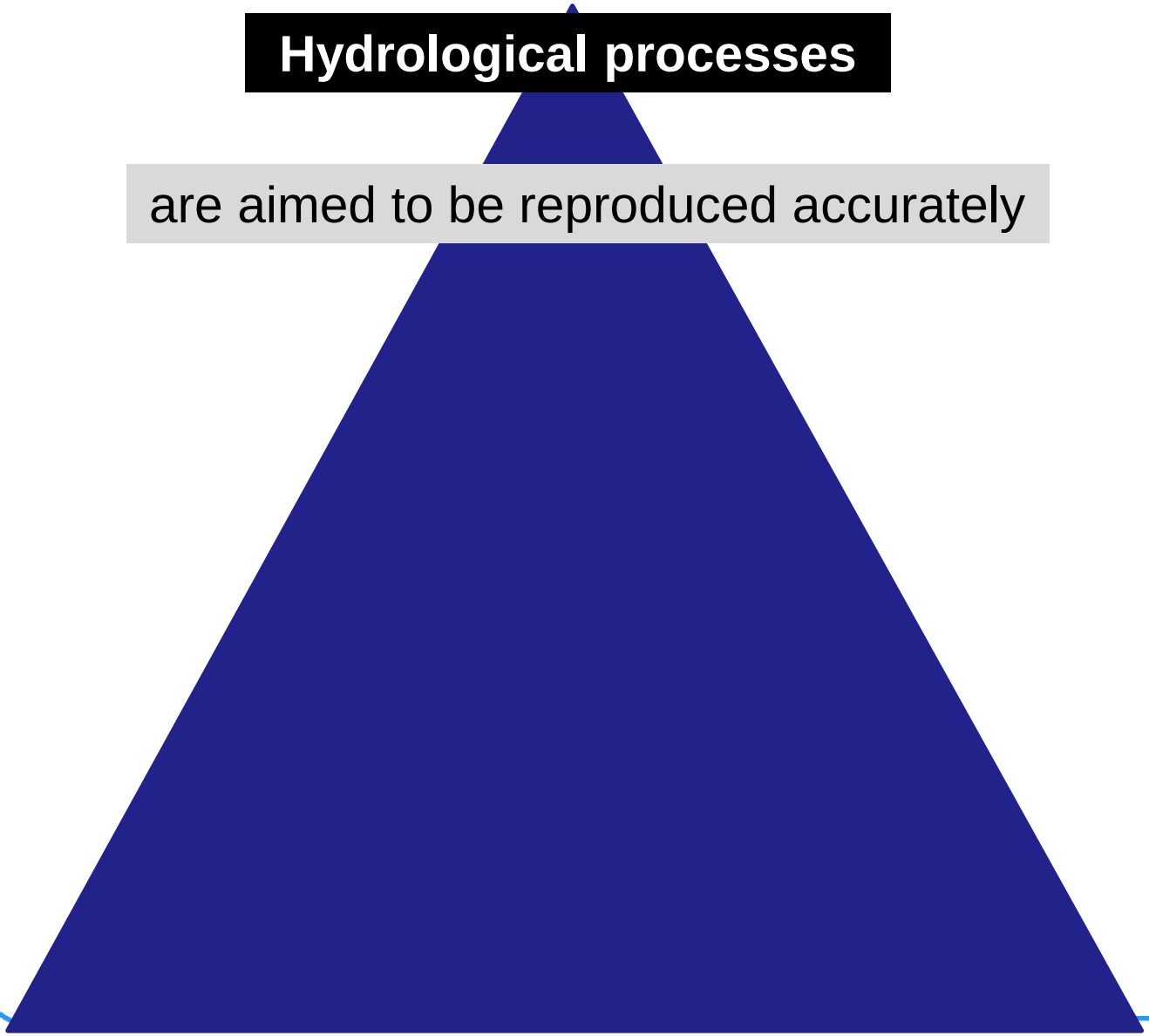
SWAT – selected processes and parameters

SWAT 3S (Pfannerstill et al., 2014a, HP)

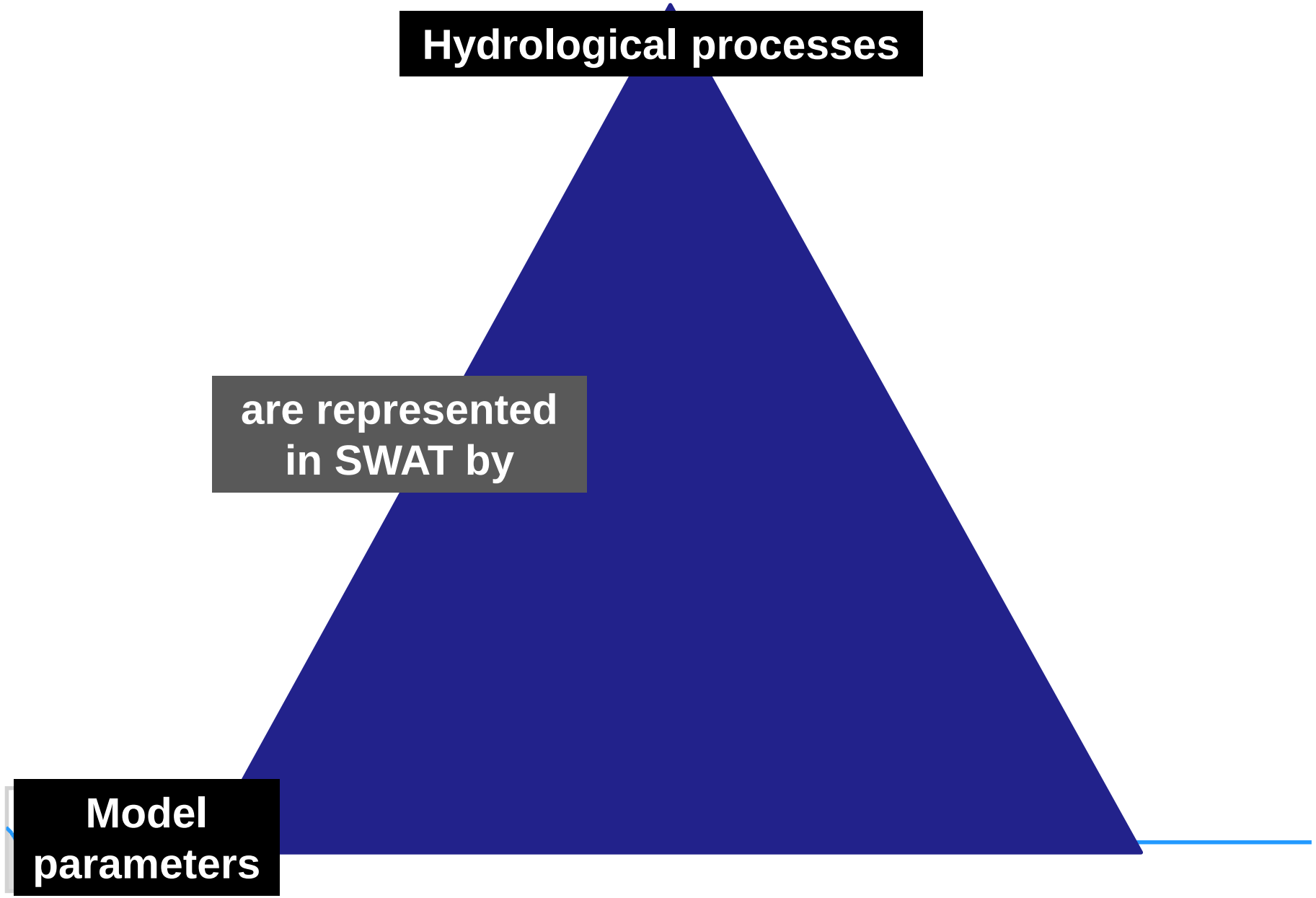


Flowchart modified from Guse et al. (2014, HP)

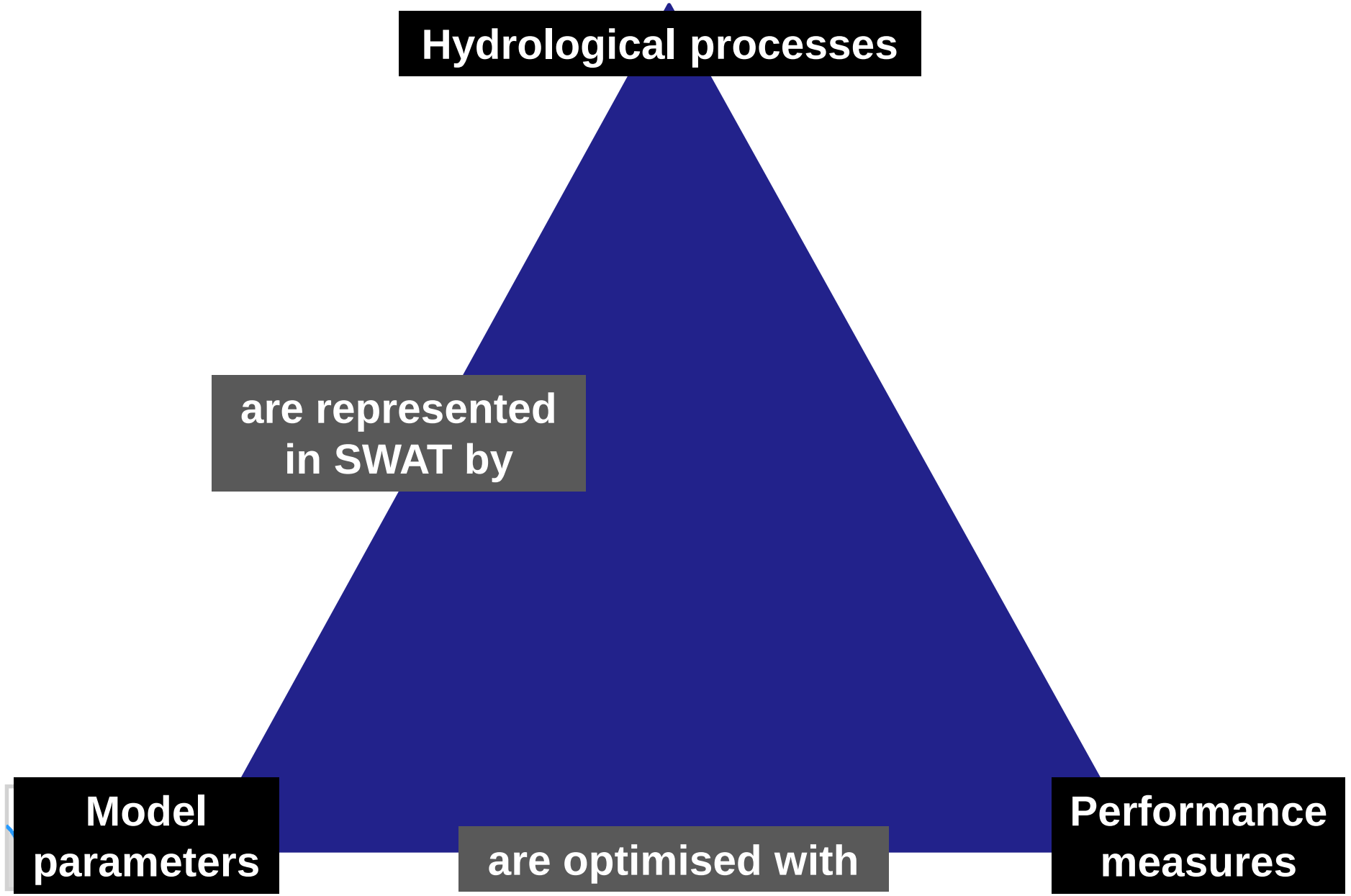
Diagnostic model tools



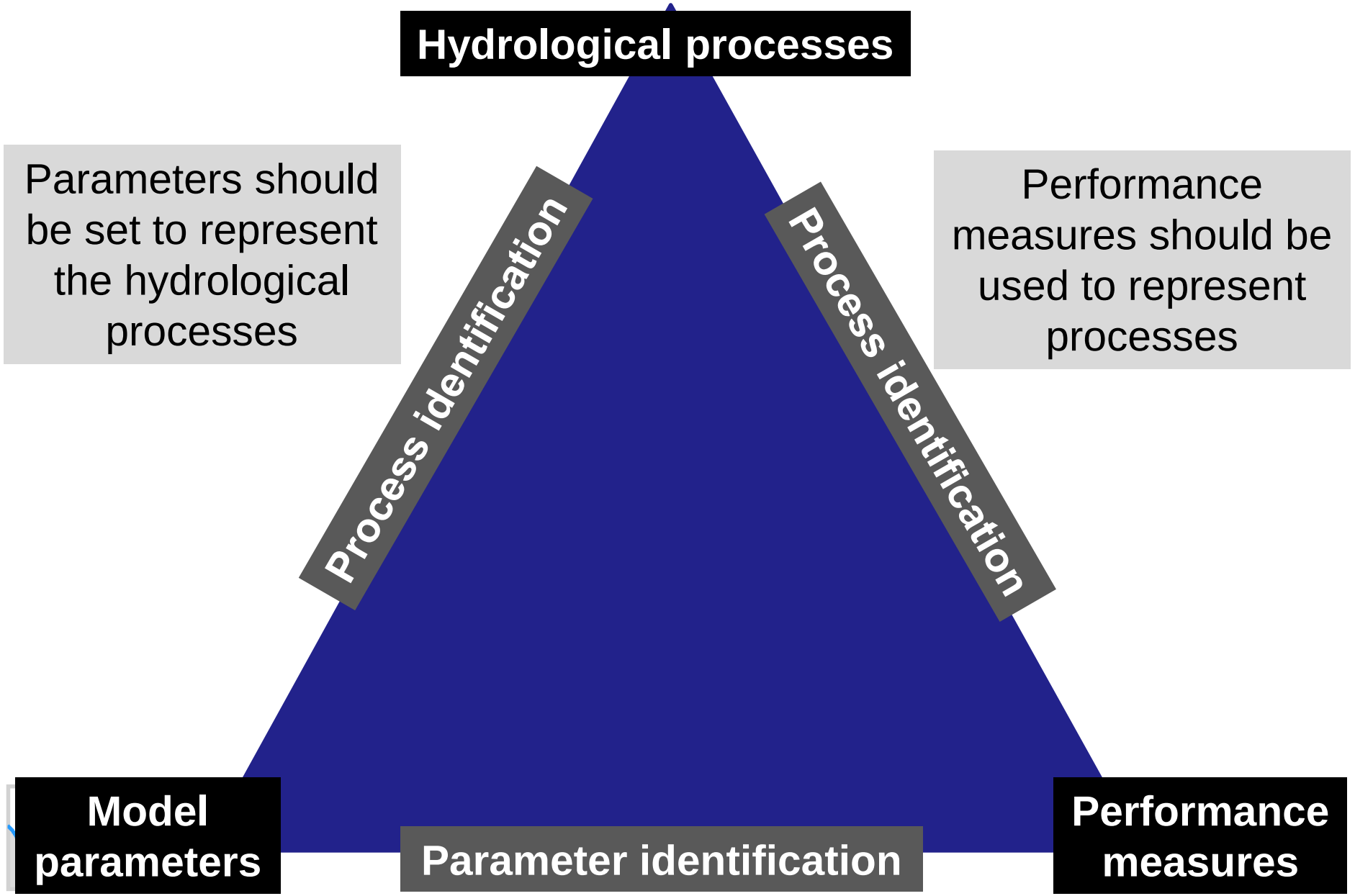
Diagnostic model tools



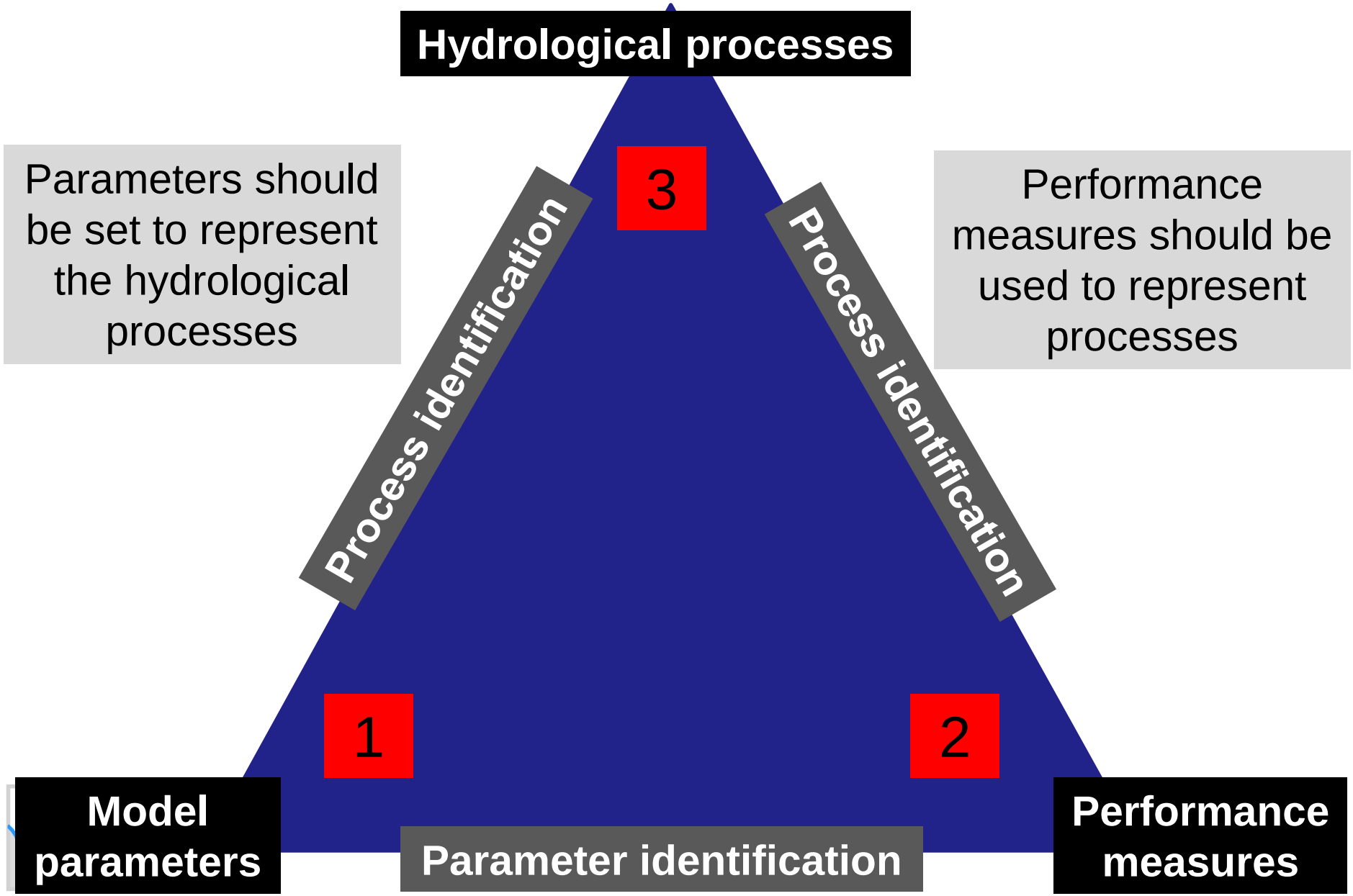
Diagnostic model tools



Hydrological consistency



Diagnostic model tools



Sequence of diagnostics

- Step 1: Temporal sensitivity analyses of parameters
- Step 2: Calibration for all flow conditions using FDC

  Select model runs that behave well in all segments of the FDC
- Step 3: Monthly pattern of parameter dominances for the different discharge magnitudes

1. Temporal parameter sensitivity analysis

Method:

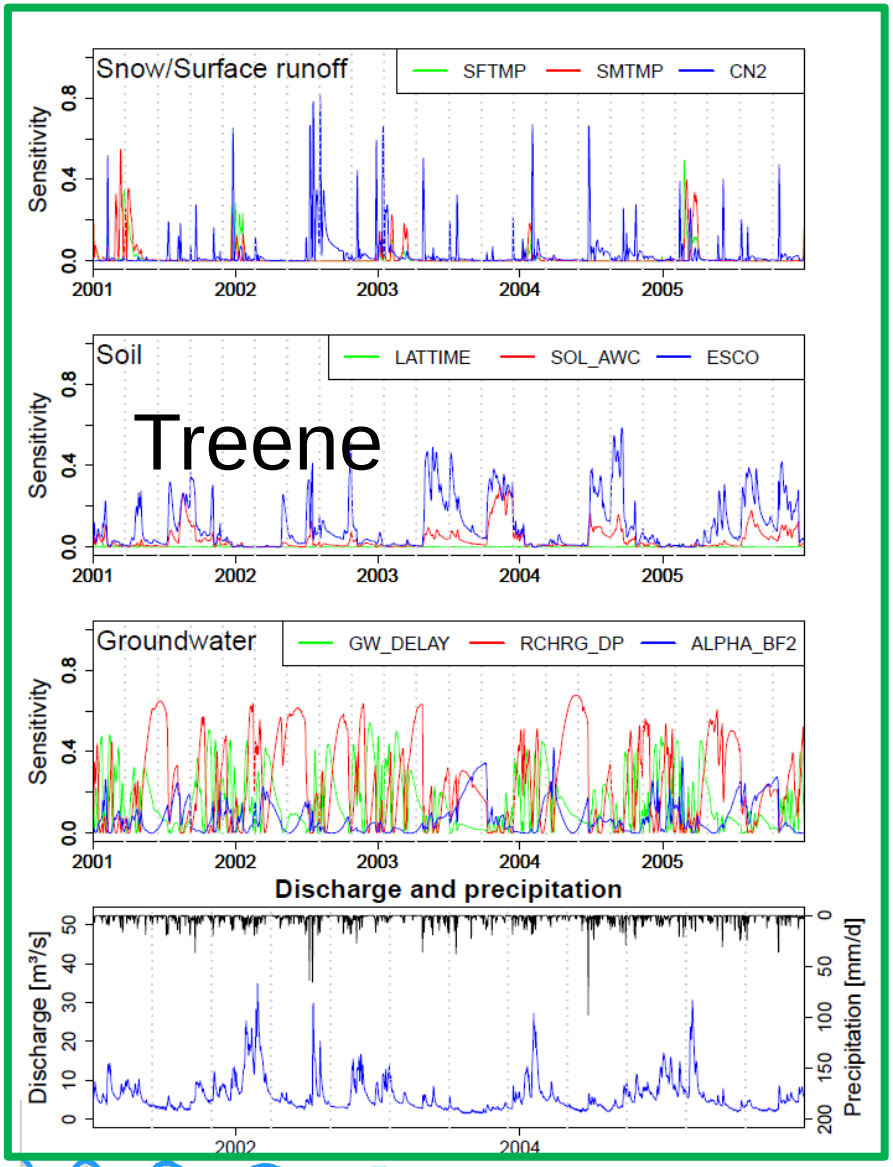
- Parameter sensitivity analysis for each day
- Temporal dynamic of parameter sensitivity analysis (TEDPAS)
- Global sensitivity analysis based on factor prioritization using the FAST algorithm
- FAST captures the whole parameter space

Result:

- Shows in which phase of the year a parameter is dominant
- Daily hierarchy of dominant model parameters

Reusser et al. (2011, WRR), Guse et al. (2014, HP)

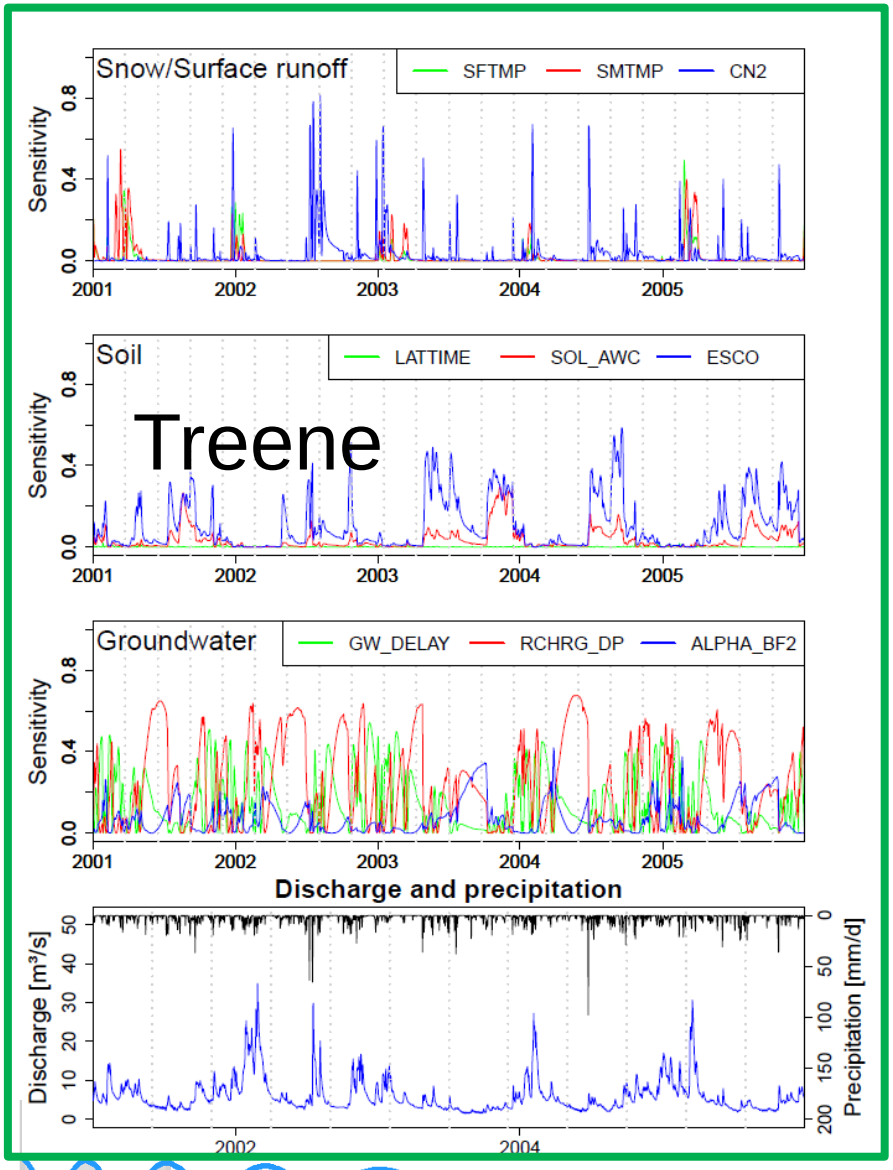
Temporal parameter sensitivity analysis

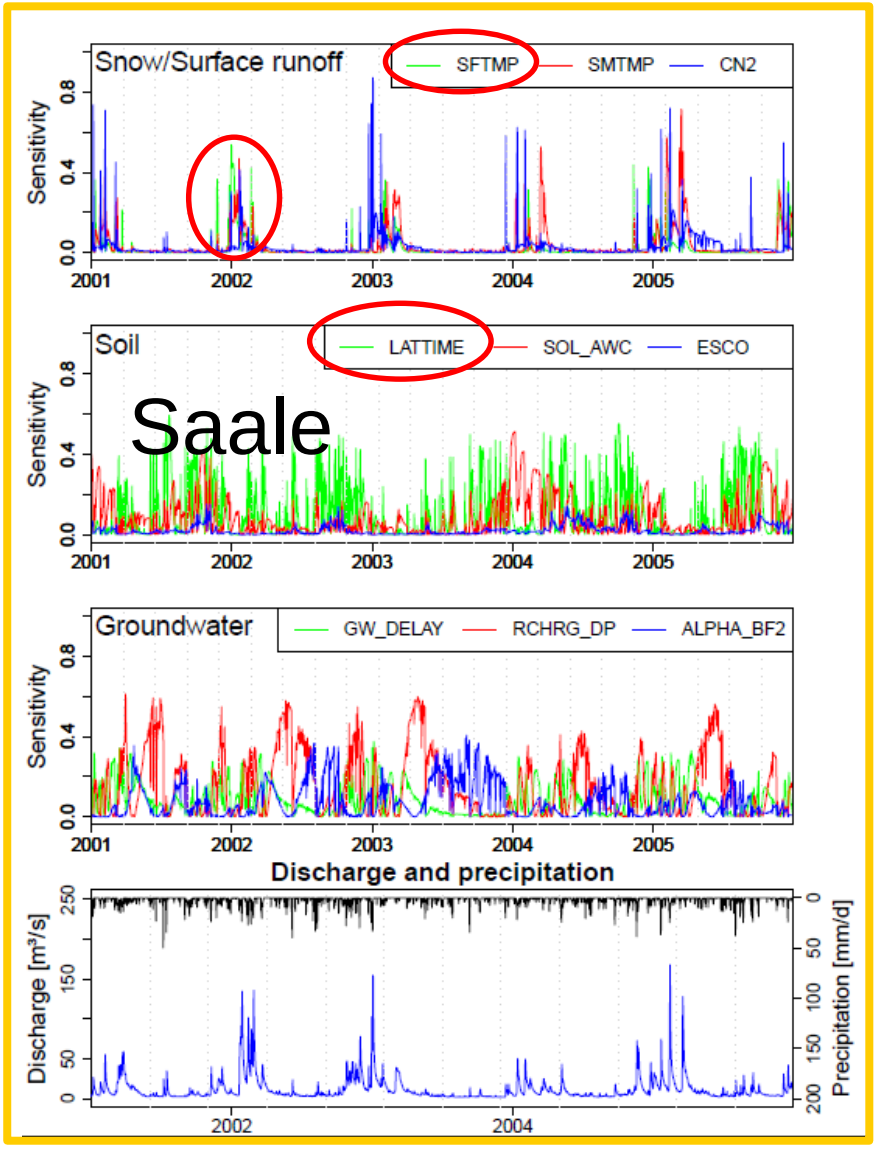


- CN2 dominant only for short phases
- At least one groundwater parameter is always dominant
- high temporal variations between the groundwater parameters

Guse et al. (in prep. for HP)

Temporal parameter sensitivity analysis





Guse et al. (in prep. for HP)

Diagnostic model tools

Hydrological processes

Parameters should be set to represent the hydrological processes

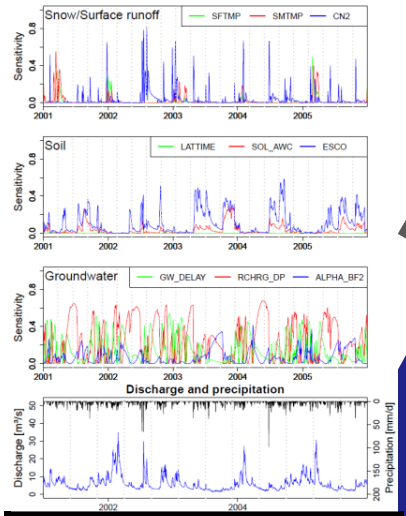
Performance measures should be used to represent processes

3

Process identification

Process identification

2



SWAT model parameters

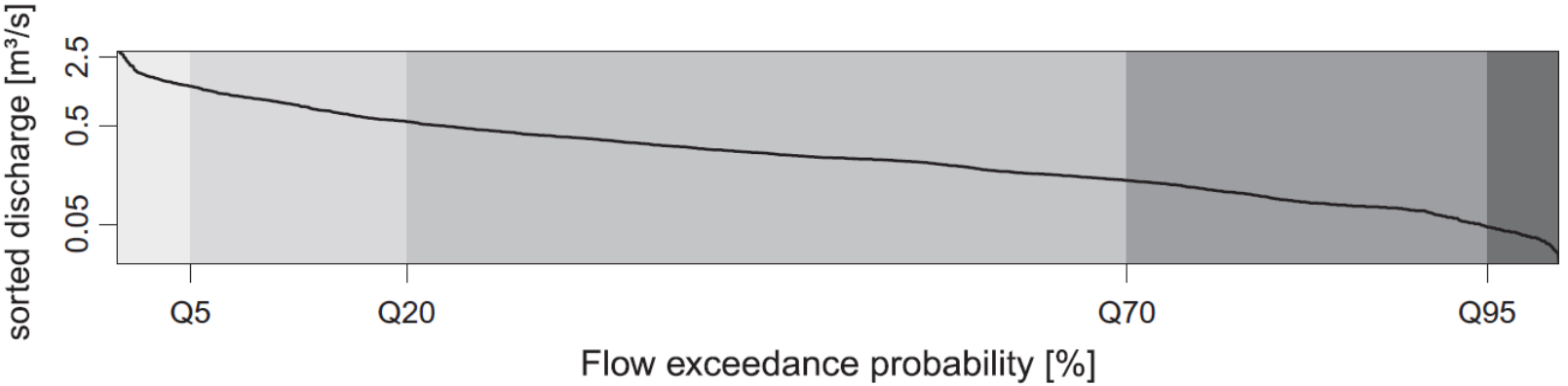
Parameter identification

Performance measures

model calibration for different flow conditions

Method:

- Stepwise intersection of good model runs for five segments of the flow duration curve (FDC)
- Evaluation with separate RSR for each segment

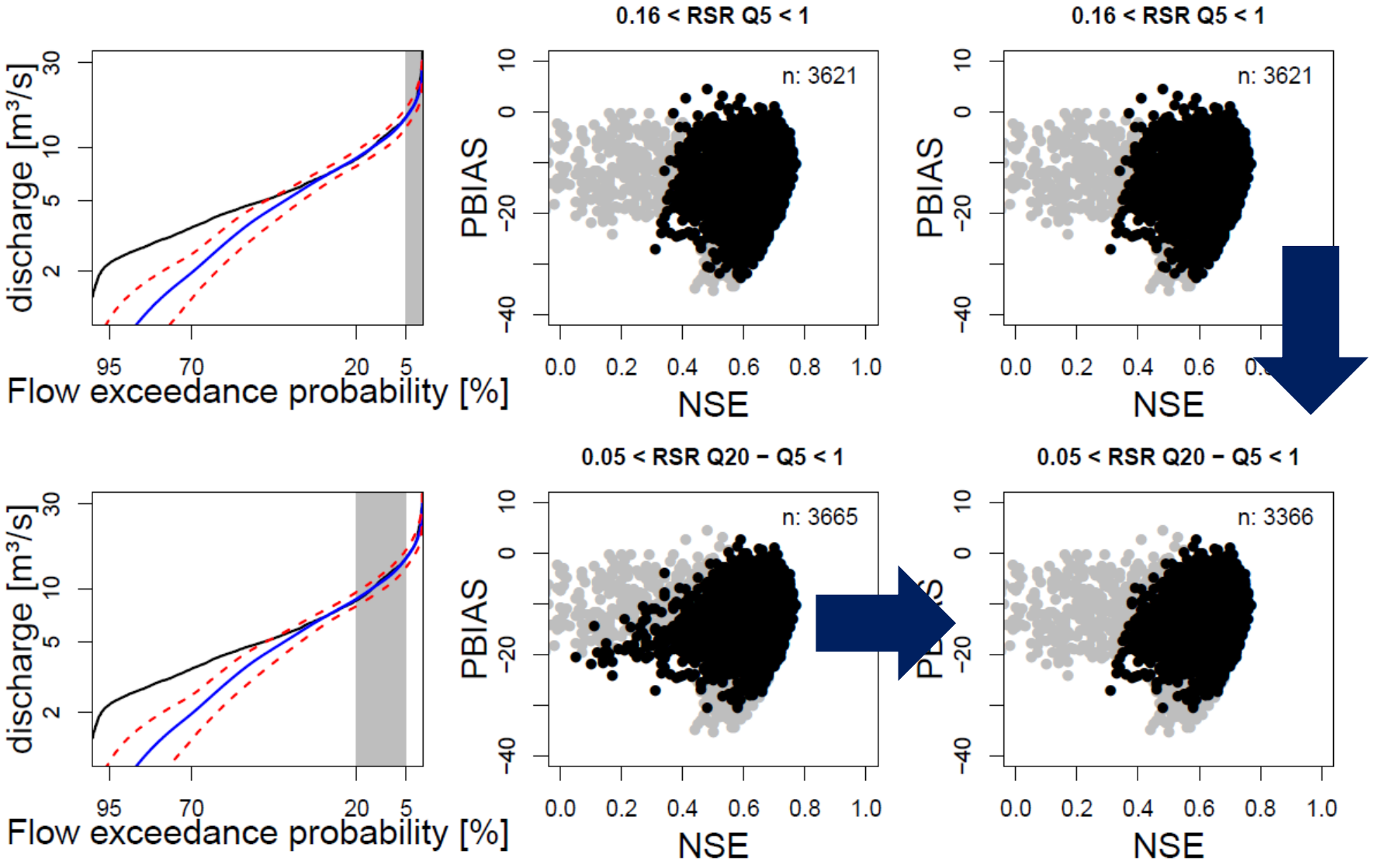


Result:

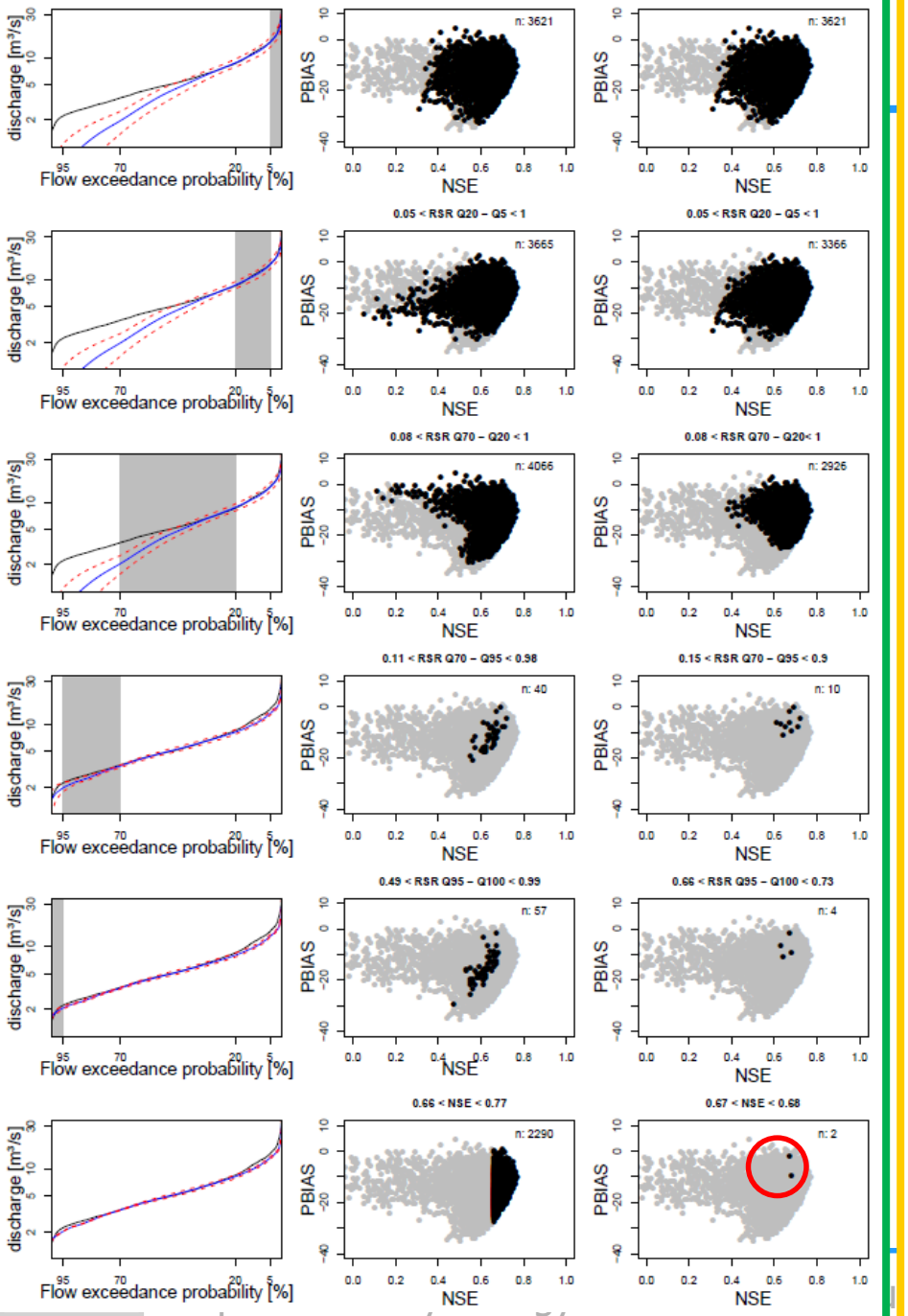
- Calibrated SWAT model reproduce all discharge magnitudes in a similar model performance

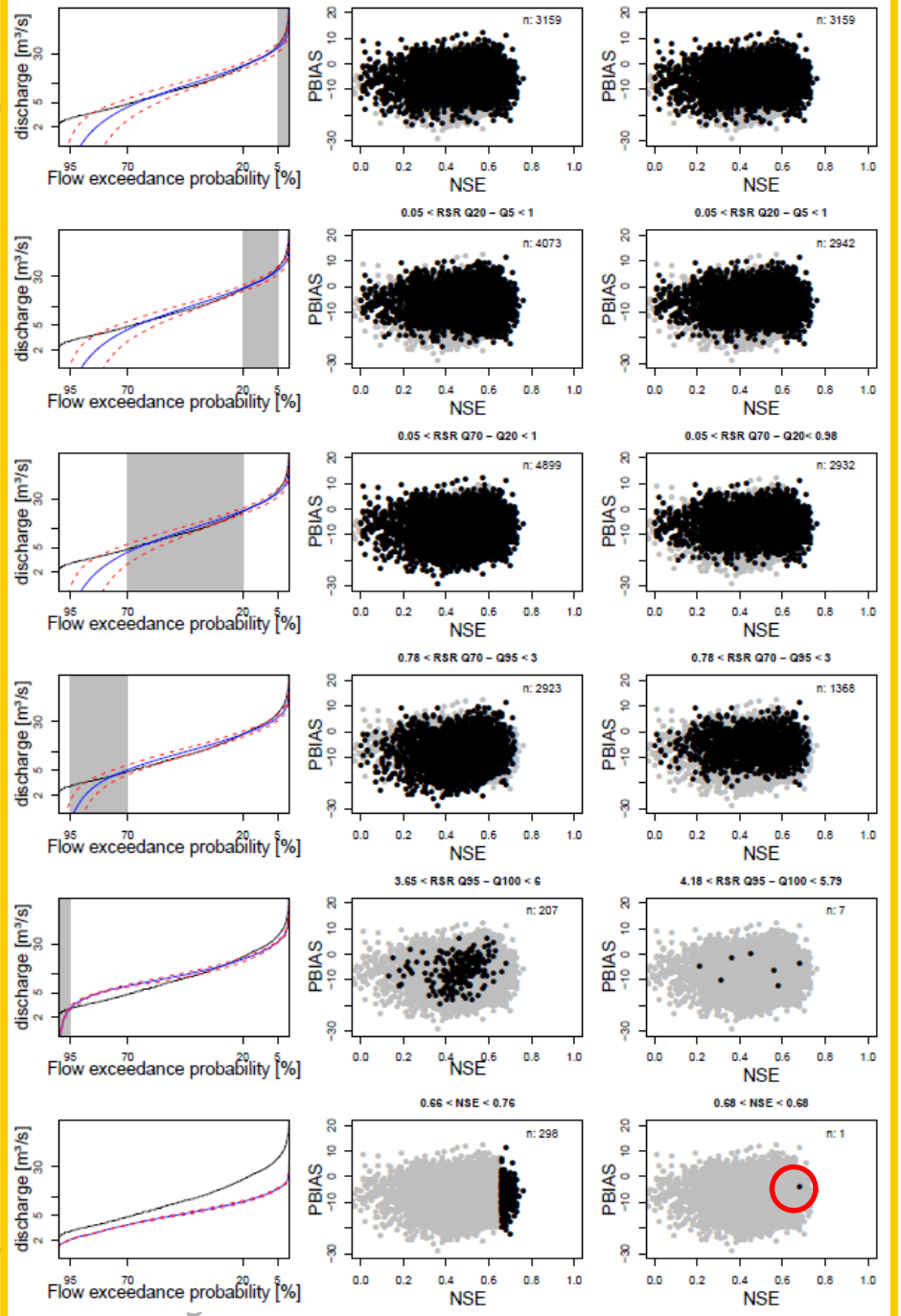
Pfannerstill et al. (2014b, JH)

Smart model calibration



Pfannerstill et al. (2014b, JH)


0.16 < RSR Q5 < 1
n: 3621
0.16 < RSR Q5 < 1
n: 3621
0.05 < RSR Q20 – Q5 < 1
n: 3665
0.05 < RSR Q20 – Q5 < 1
n: 3366
0.08 < RSR Q70 – Q20 < 1
n: 4066
0.08 < RSR Q70 – Q20< 1
n: 2926
0.11 < RSR Q70 – Q95 < 0.98
n: 40
0.15 < RSR Q70 – Q95 < 0.9
n: 10
0.49 < RSR Q95 – Q100 < 0.99
n: 57
0.66 < RSR Q95 – Q100 < 0.73
n: 4
0.66 < NSE < 0.77
n: 2290
0.67 < NSE < 0.68
n: 2
discharge [m³/s]
Flow exceedance probability [%]
PBIAS
NSE


0.12 < RSR Q5 < 1
n: 3159
0.12 < RSR Q5 < 1
n: 3159
0.05 < RSR Q20 – Q5 < 1
n: 4073
0.05 < RSR Q20 – Q5 < 1
n: 2942
0.05 < RSR Q70 – Q20 < 1
n: 4899
0.05 < RSR Q70 – Q20< 0.98
n: 2932
0.78 < RSR Q70 – Q95 < 3
n: 2923
0.78 < RSR Q70 – Q95 < 3
n: 1368
3.65 < RSR Q95 – Q100 < 6
n: 207
4.18 < RSR Q95 – Q100 < 5.79
n: 7
0.66 < NSE < 0.76
n: 298
0.68 < NSE < 0.68
n: 1
discharge [m³/s]
Flow exceedance probability [%]
PBIAS
NSE

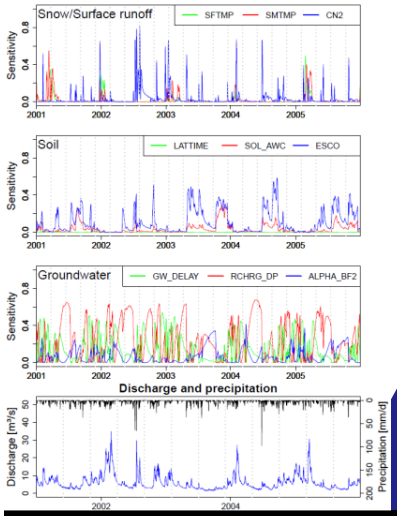
Diagnostic model tools

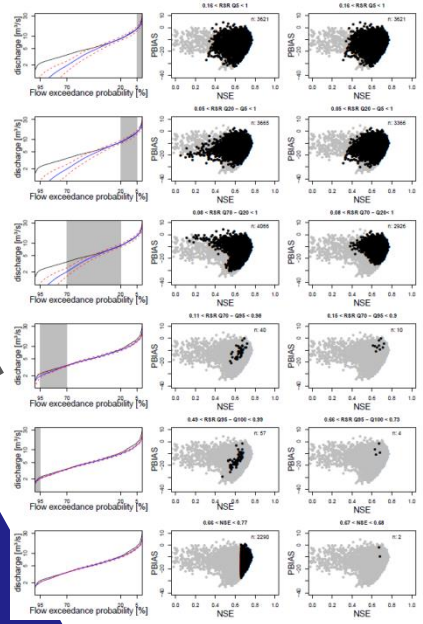
Hydrological processes

3

Process identification

Process identification





SWAT model parameters

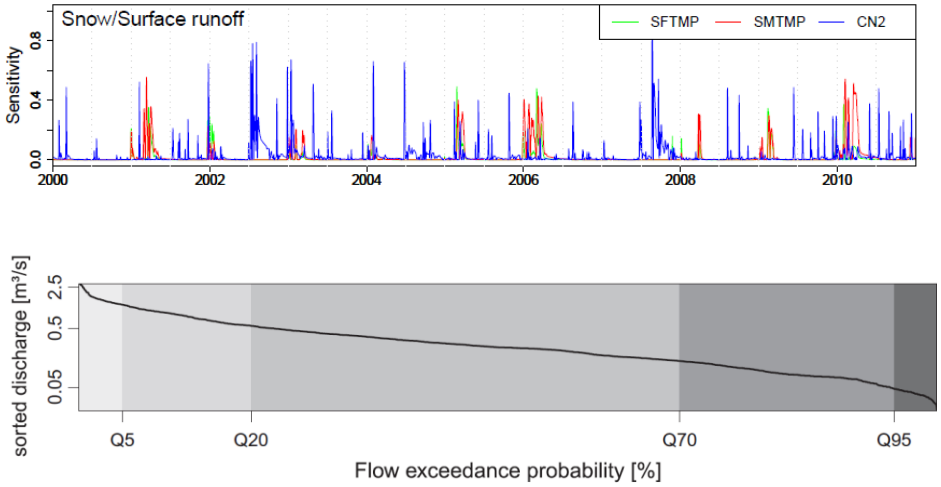
Parameter identification

Performance measures

Typical patterns of temporal parameter dynamic

Method:

- Monthly averaging of daily parameter sensitivities separately for the five FDC segments

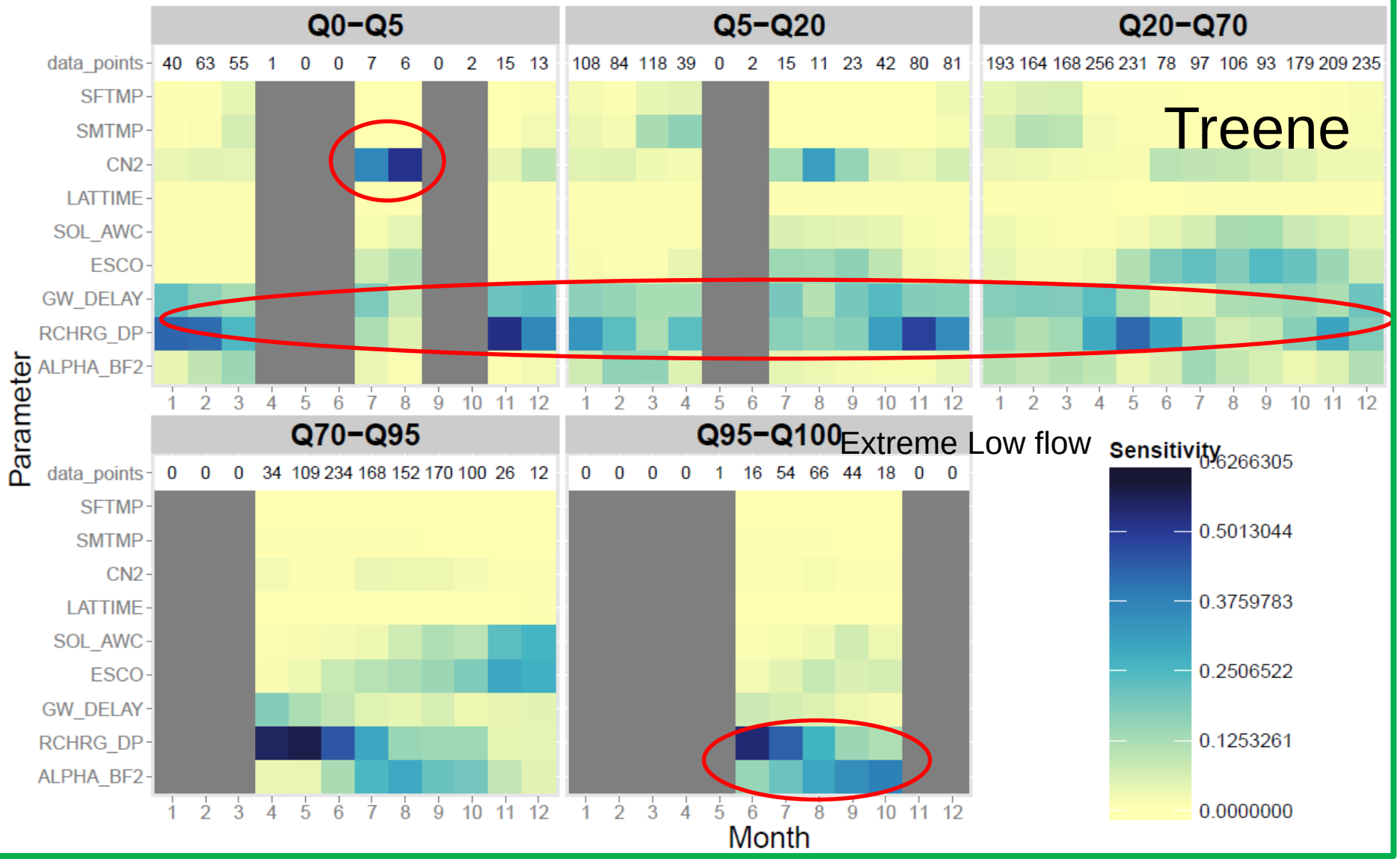


Result:

- Monthly pattern of parameter dominances for the different discharge magnitudes

Guse et al. (in prep. for HP)

Typical patterns of temporal parameter dynamic



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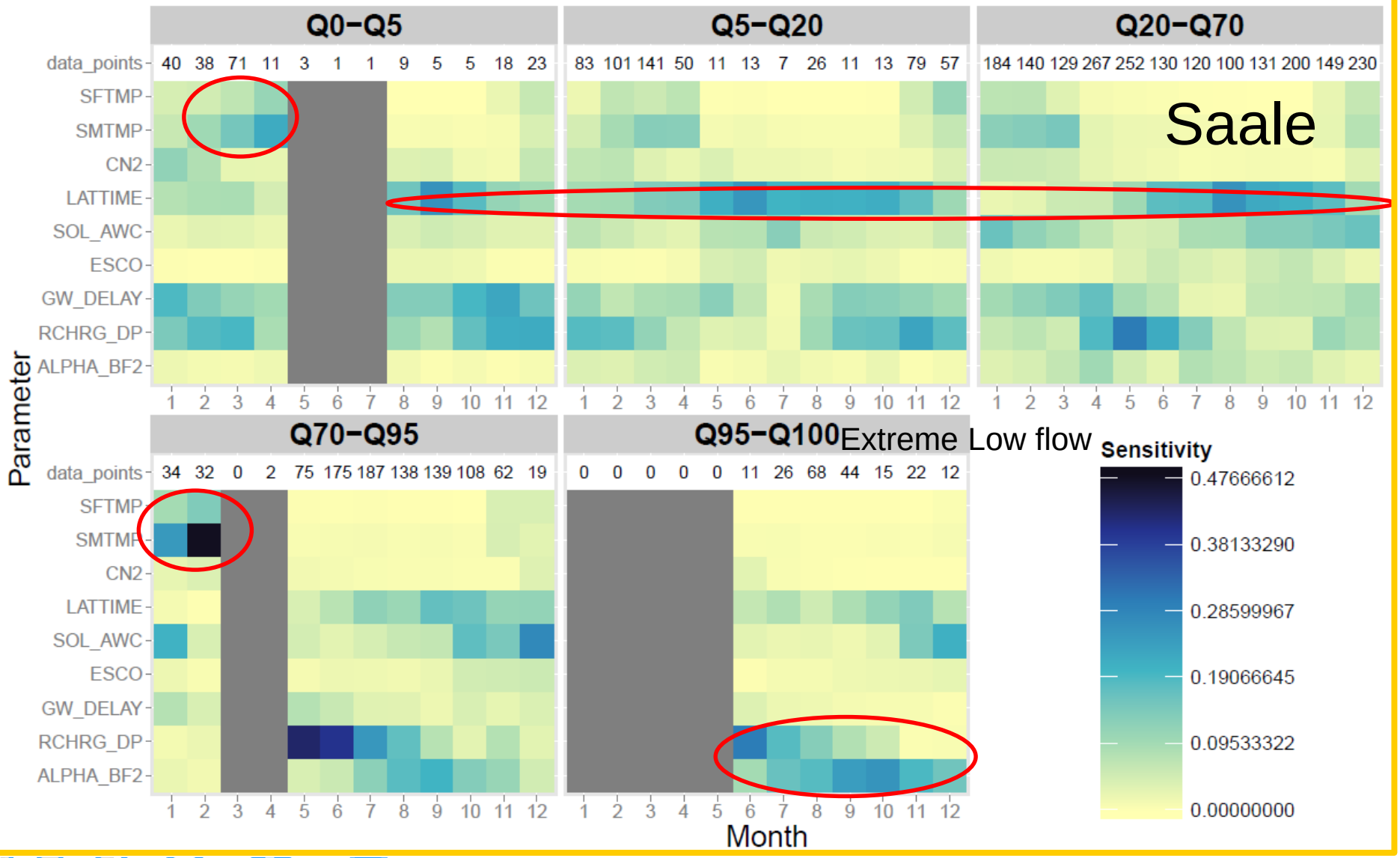
Typical patterns of temporal parameter dynamic



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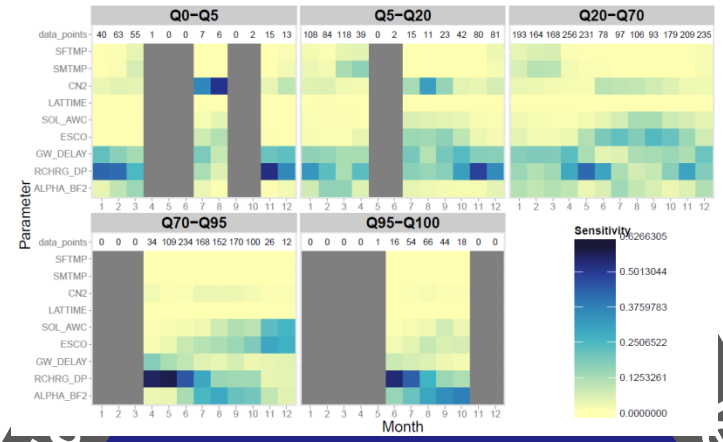
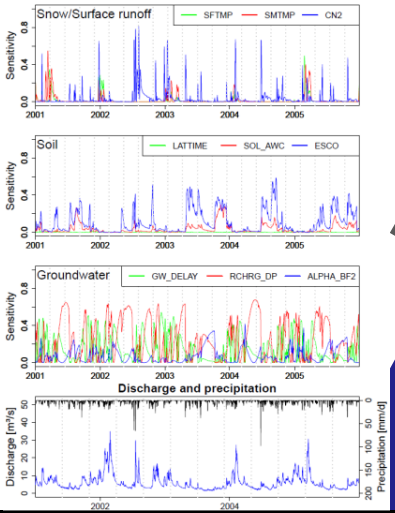
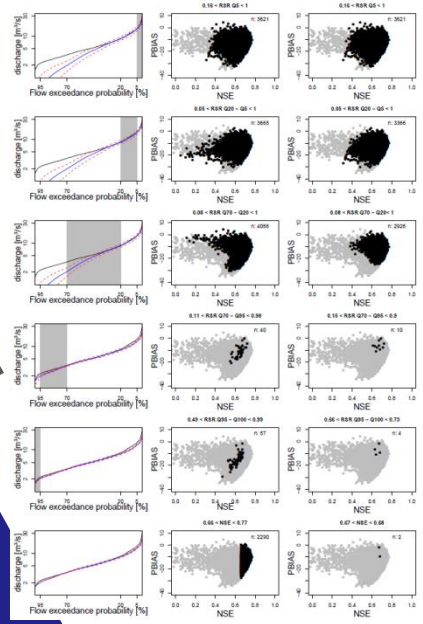
Diagnostic model tools

Hydrological processes





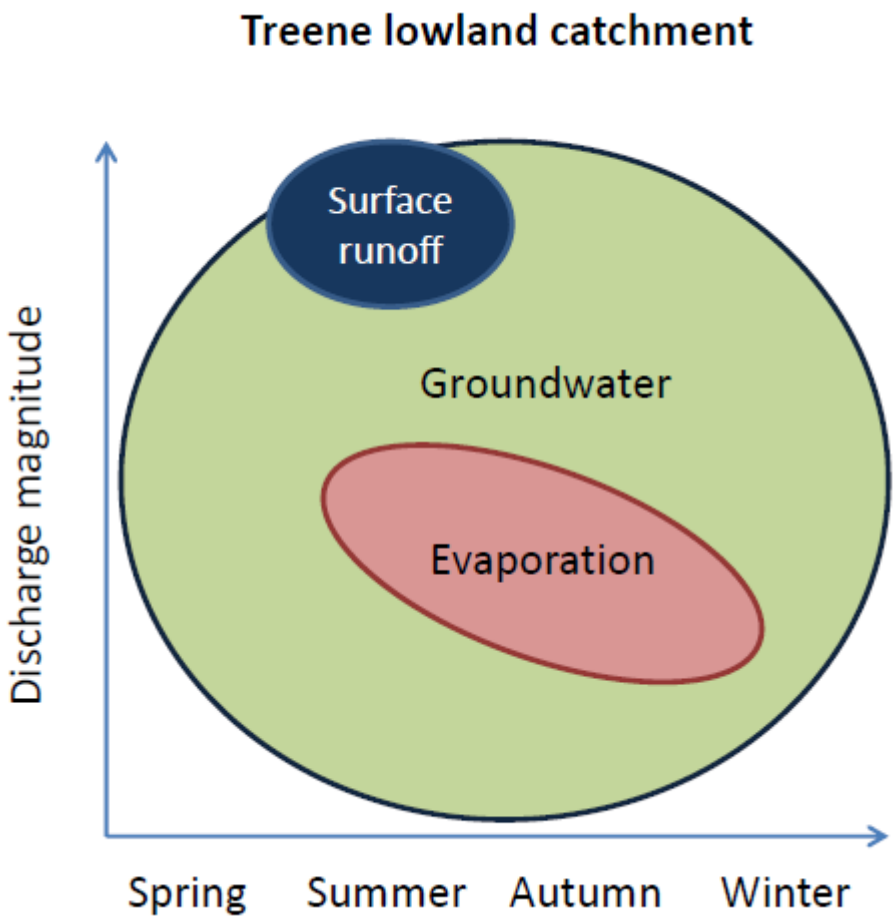


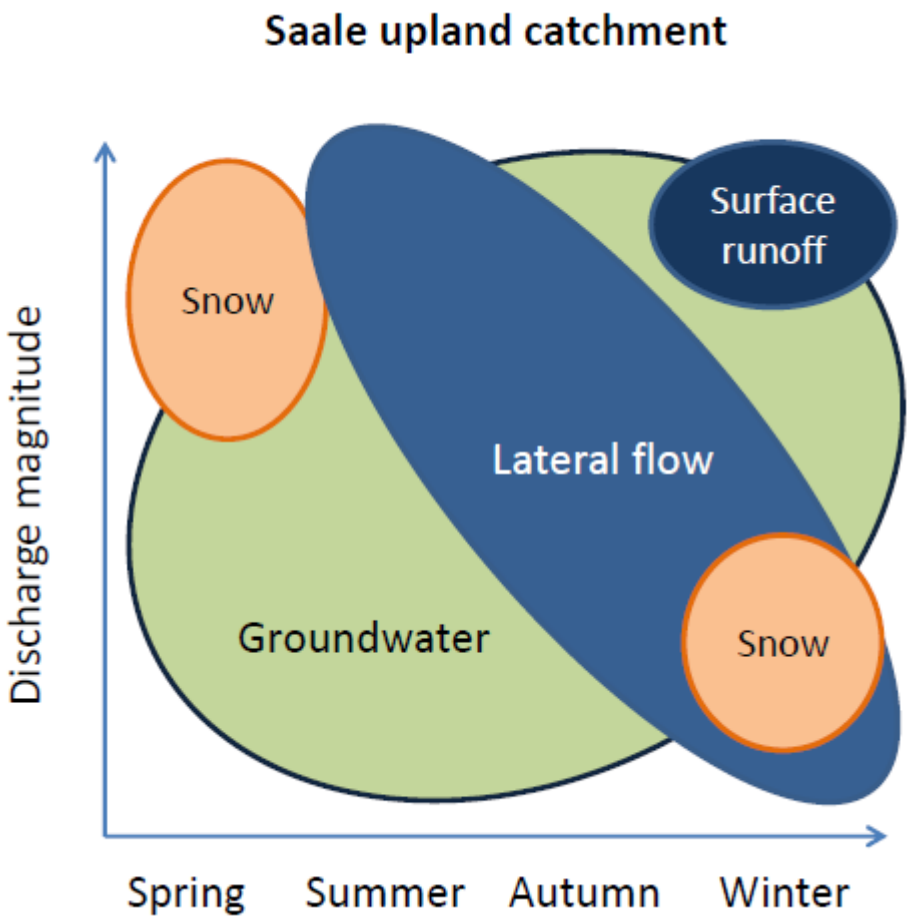
SWAT model parameters

Parameter identification

Performance measures

Summarising process control





Guse et al. (in prep. for HP)

Concluding remarks

- Combination of temporal dynamic of dominant model parameters and corresponding processes with different discharge conditions leads to a typical pattern of the hydrological behaviour in the two study catchments
- The three diagnostic tools lead to a better understanding of the process representation in the SWAT model

References:

- *Guse, B.; Reusser, D.E.; Fohrer, N. (2014): How to improve the representation of hydrological processes, Hydrol. Process., 28, 2651–2670.*
- *Pfannerstill, M.; Guse, B.; Fohrer, N.(2014a): A multi-storage groundwater concept for the SWAT model to emphasize nonlinear groundwater dynamics in lowland catchments, Hydrol. Process., 28, 5599–5612.*
- *Pfannerstill, M.; Guse, B.; Fohrer, N. (2014b): Smart low flow signature metrics for an improved overall performance evaluation of hydrological models, J. Hydrol., 510, 447–458.*
- *Reusser, D.E.; Buytaert, W.; Zehe, E. (2011): Temporal dynamics of model parameter sensitivity for computationally expensive models with FAST (Fourier Amplitude Sensitivity Test), Water Resour. Res., 47(7), doi:10.1029/2010WR009.*

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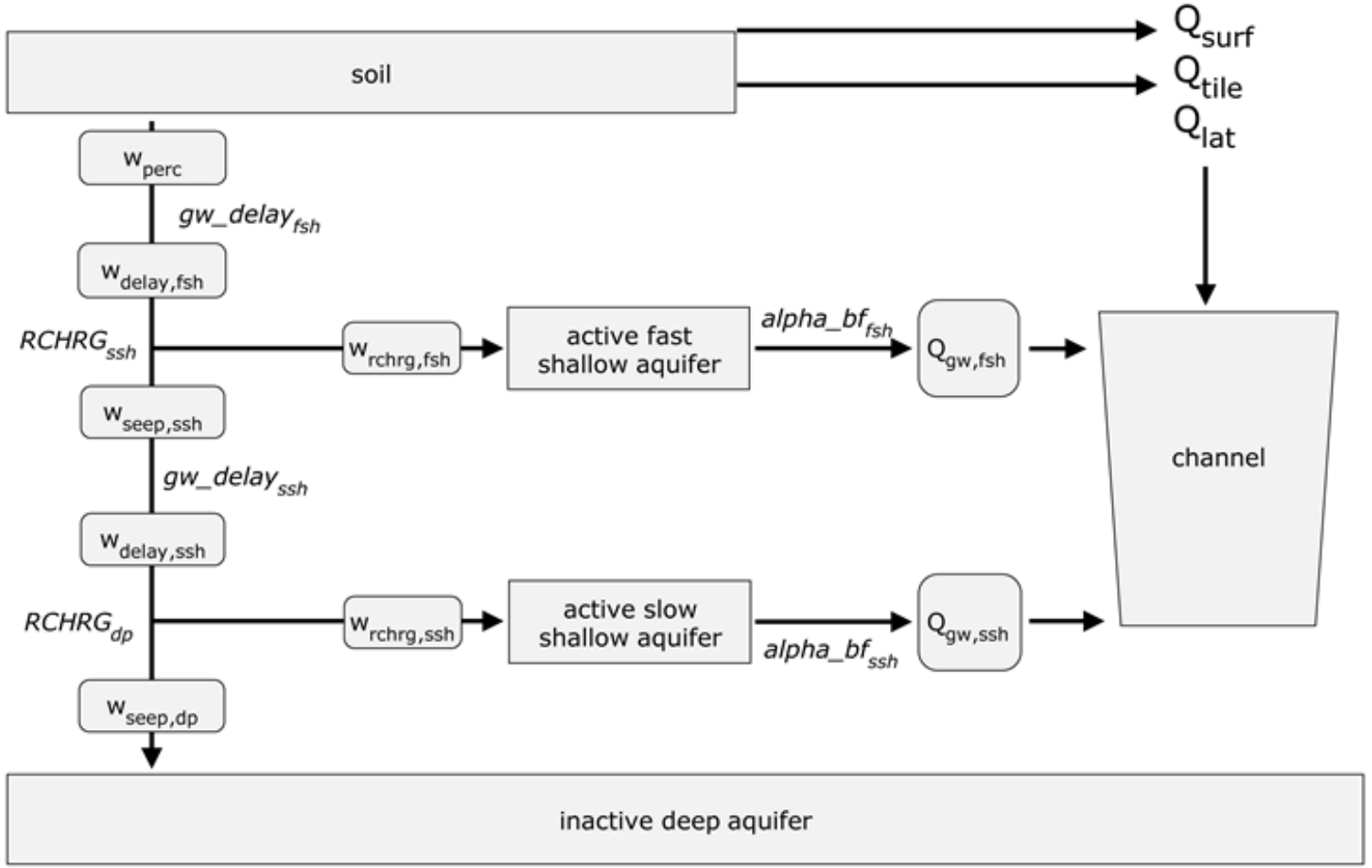
SWAT 3S

Modified SWAT-Version with two active shallow aquifers and one inactive deep aquifer



Pfannerstill et al. (2014, HP)