Temporal analysis of parameter sensitivity and model performance to improve the representation of hydrological processes in SWAT for a German lowland catchment

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Temporal diagnostic analysis

Diagnostic model analysis

- Relationship between model structure and hydrological processes in a catchment
- Identification of dominant hydrological processes and patterns
- Improved understanding of processes and their representation in models
- Diagnostic information by temporally resolved analysis for each time step

-> Temporal diagnostic analysis

Gupta et al. (2008, HP), Yilmaz et al. (2008, WRR), Reusser and Zehe (2011, WRR)

Temporal diagnostic methods

1. When are different model parameters dominant?

Temporal dynamics of parameter sensitivity

2. What are temporally reoccuring patterns of model performance?

Temporal dynamics of model performance

3. What model parameters are dominating in periods of poor model performance?

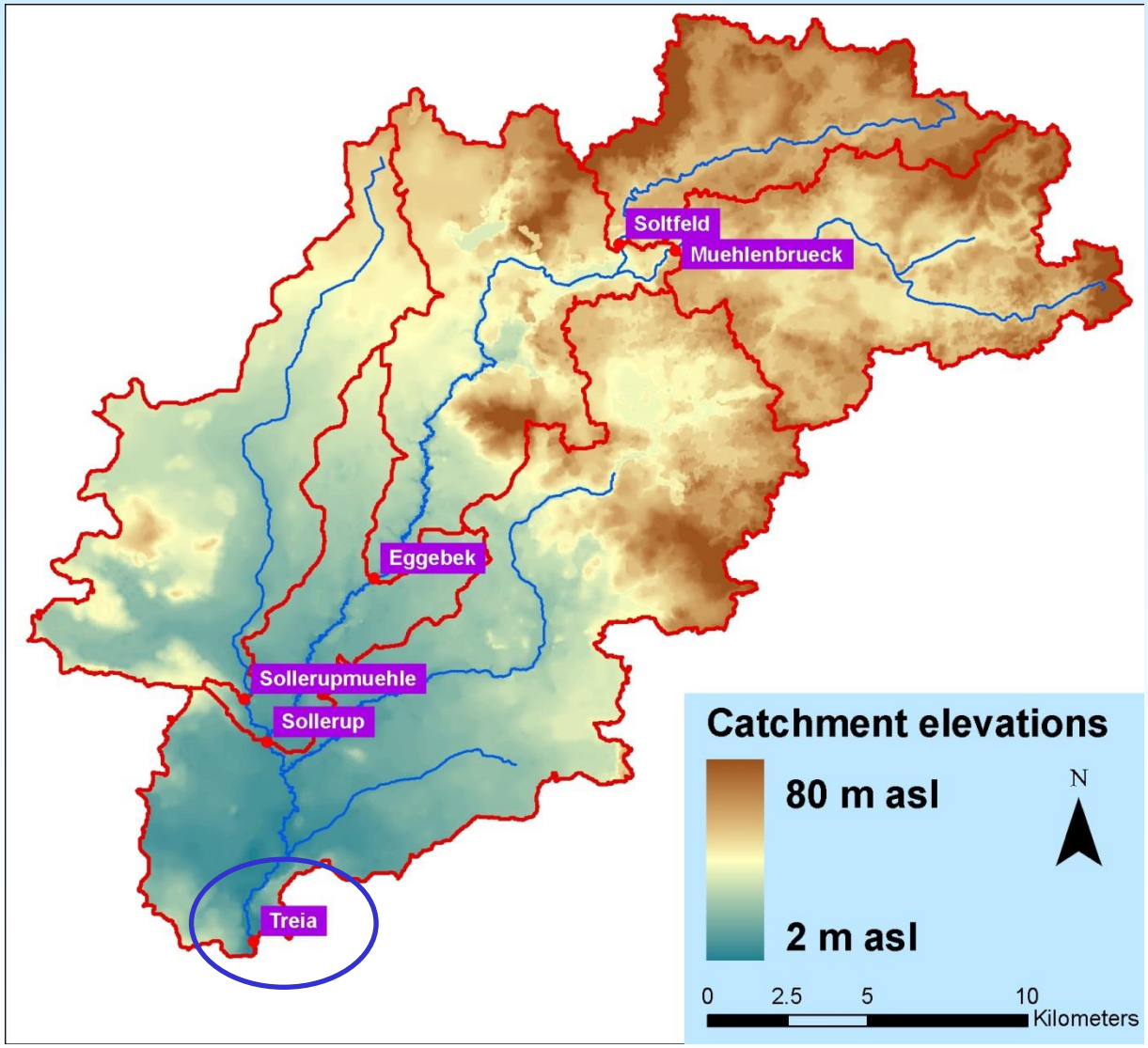
Joined temporal analysis of both methods

Detection of limiting model components with structural failures

Reusser and Zehe (2011, WRR), Guse et al. (2013, HP, in press)

Study area: Treene catchment

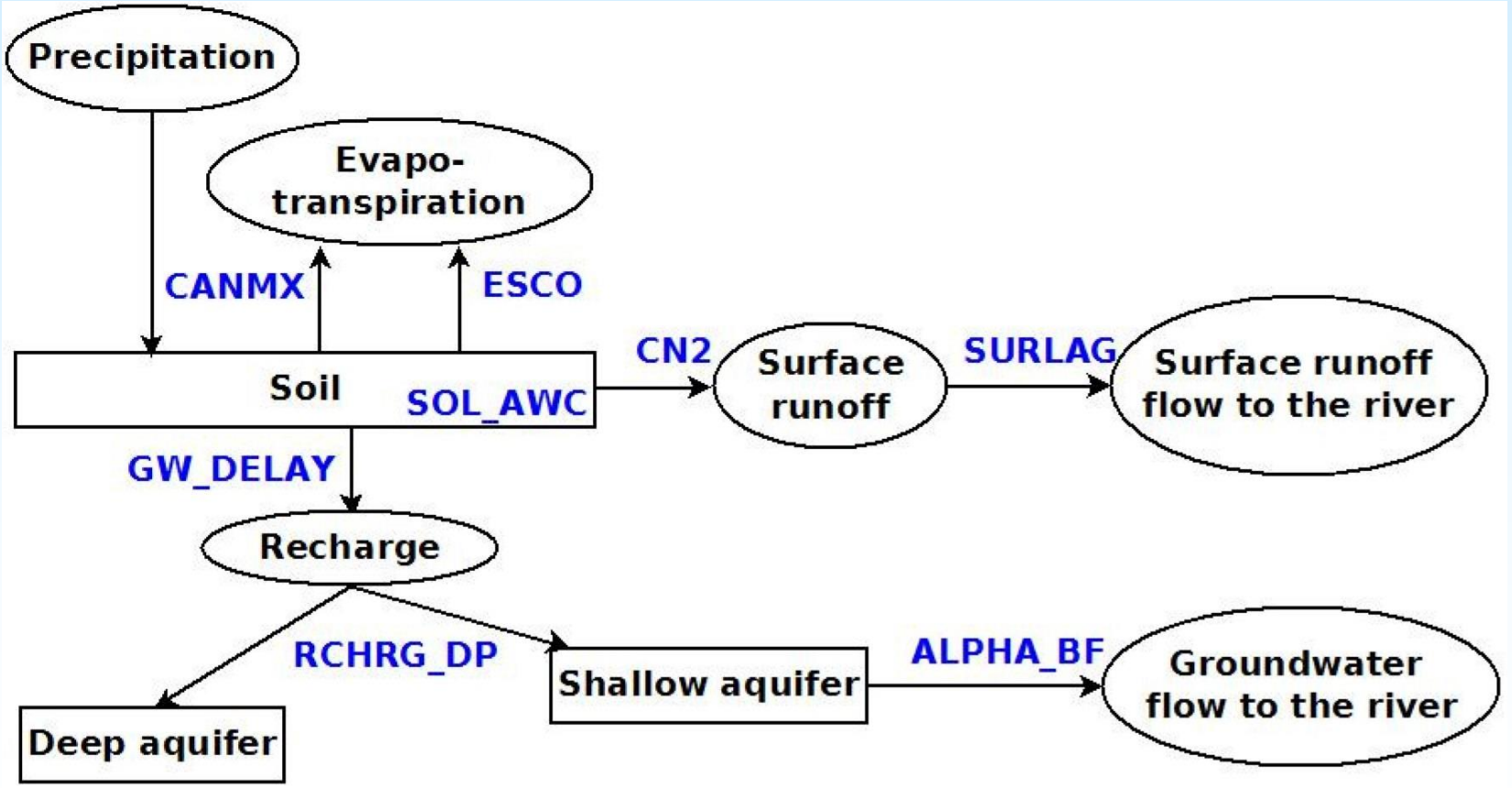
- Treene as a lowland catchment in Northern Germany
- Shallow groundwater interacting with the stream
- Catchment size (Treia): 481 km²
- 6 hydrological stations
- Focus on results for station Treia



DEM (LVERMA-SH), River network (LAND-SH)

SWAT model parameters

- Selection of eight parameters representing the relevant processes in the Treene catchment

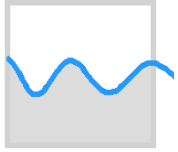


from Guse et al. (2013, HP, in press)

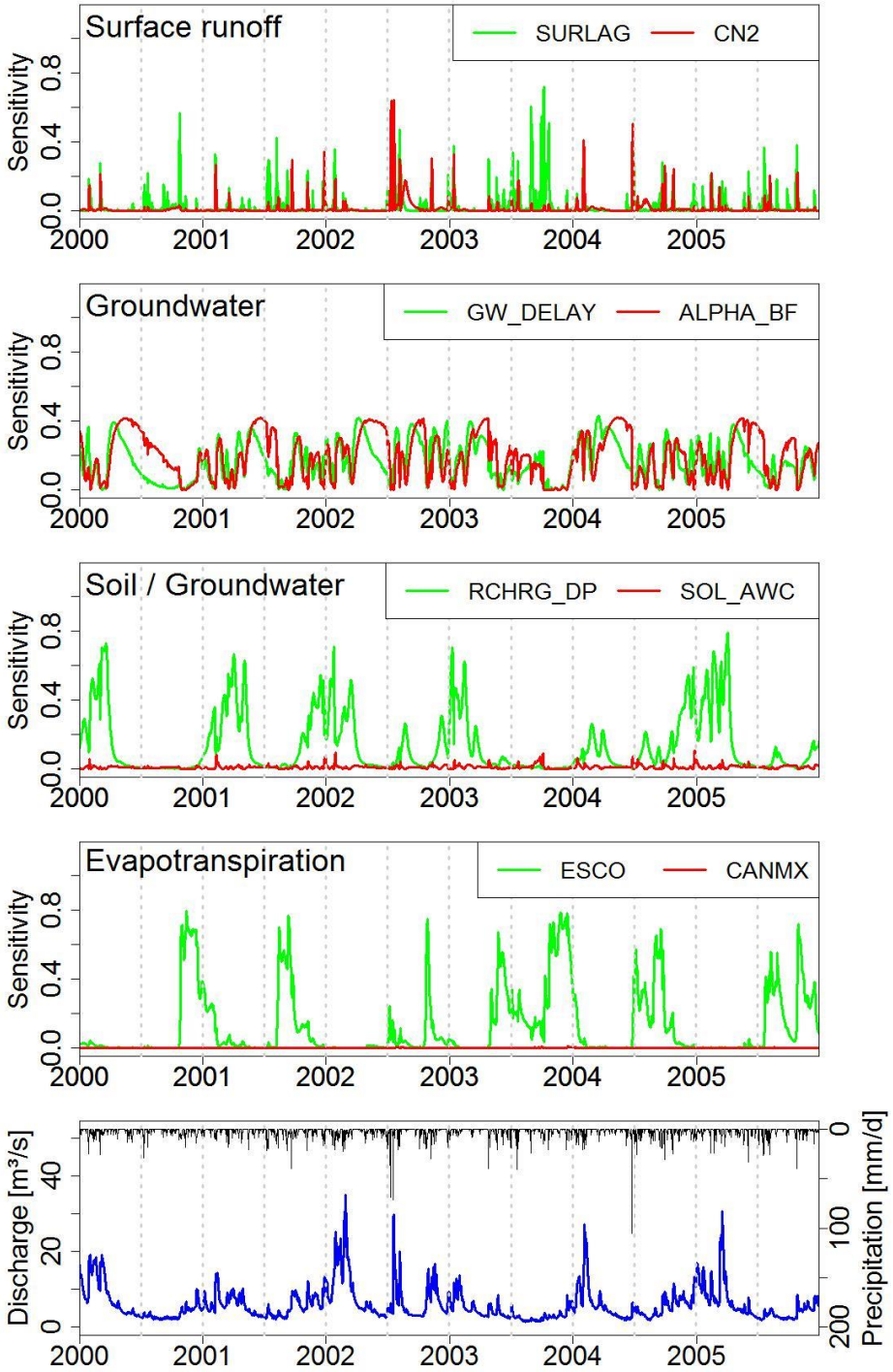
Arnold et al. (1998)

Temporal dynamic of parameter sensitivity

- Temporally resolved sensitivity analysis of modeled discharge
- Estimation by an efficient Fourier Amplitude Sensitivity Test (FAST) -> FAST.r
- Sensitivity defined as first-order partial variance for each time step
- Estimation of contribution of each parameter to total variance for each time step



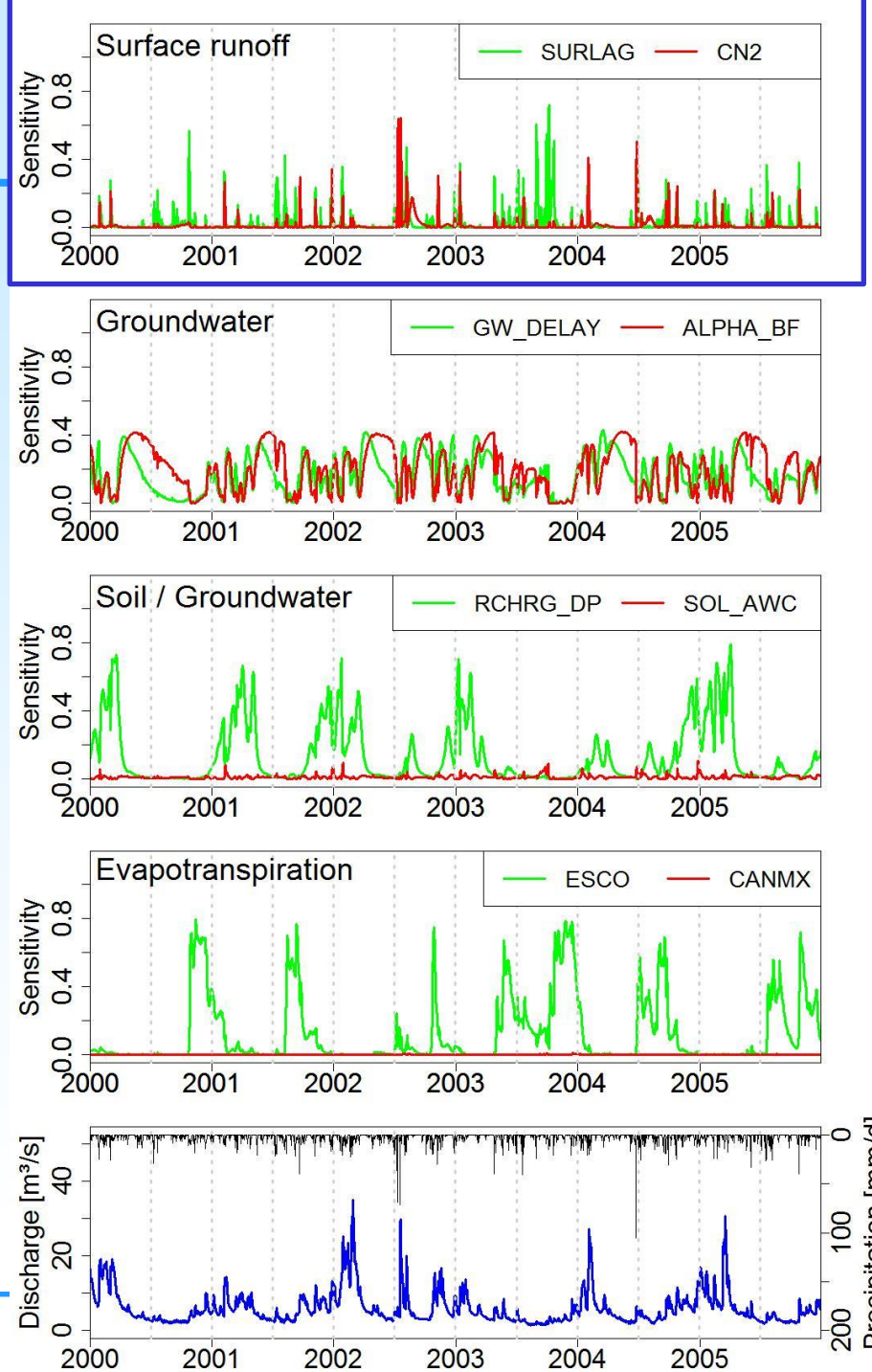
Reusser et al. (2011, WRR), Guse et al. (2013, HP, in press)



Temporal dynamic of parameter sensitivity

Surface runoff parameters

- Sensitive for short periods



Guse et al. (2013, HP, in press)

Temporal dynamic of parameter sensitivity

Surface runoff parameters

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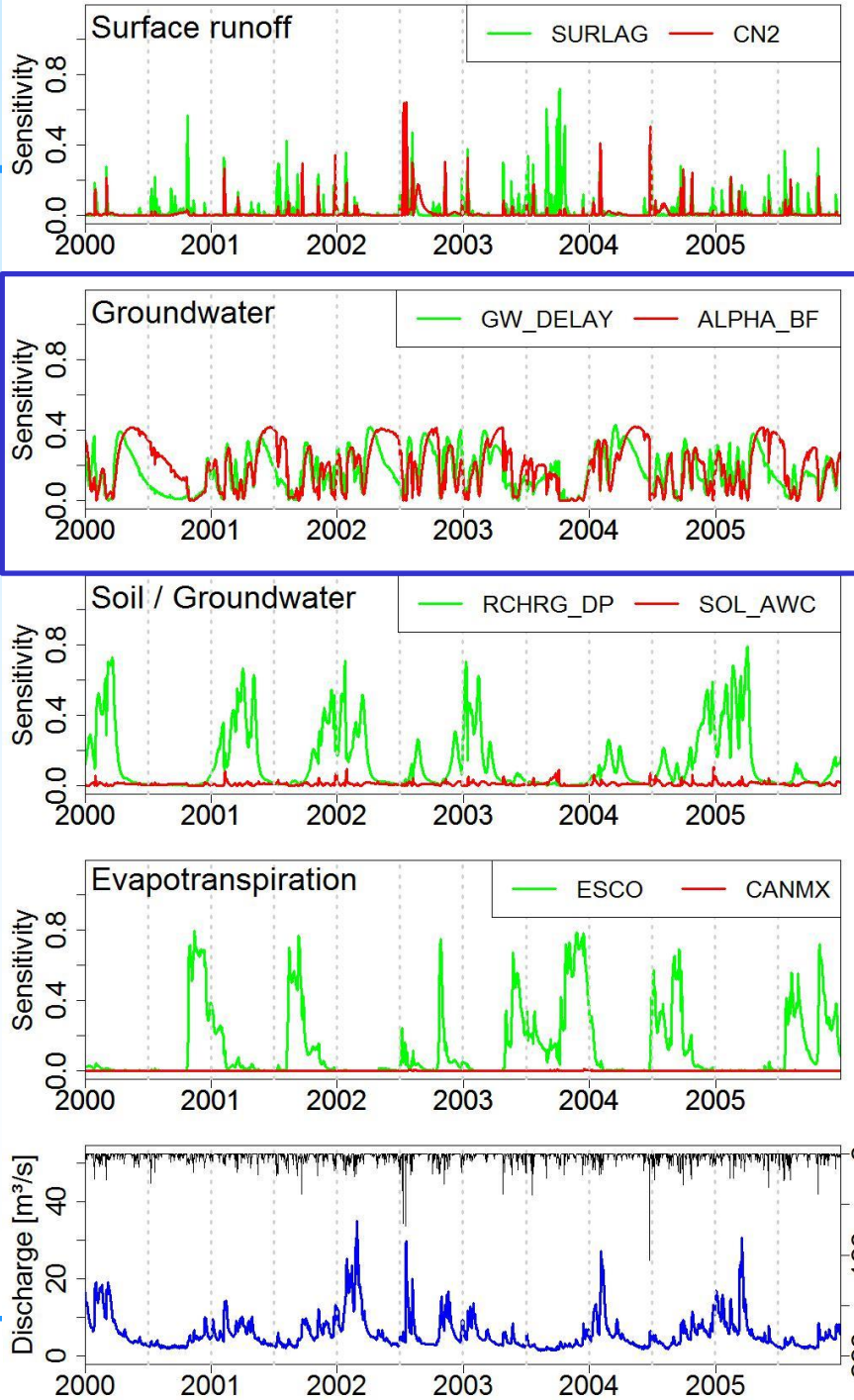
Groundwater parameters

- GW_DELAY and ALPHA_BF sensitive for long periods in recession and baseflow phases



Guse et al. (2013, HP, in press)

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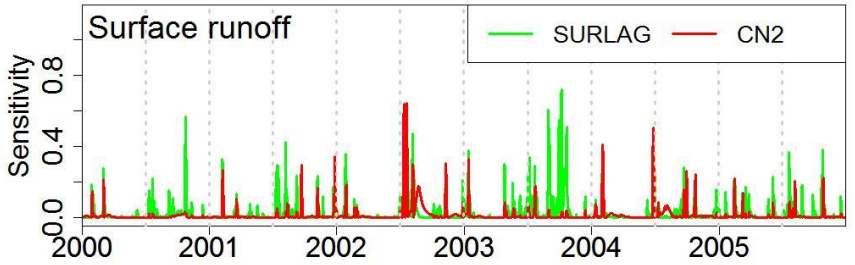
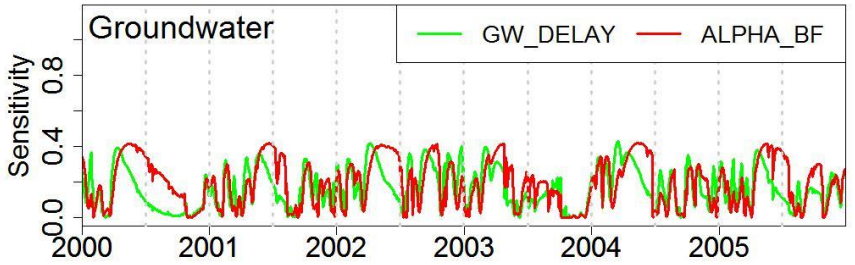
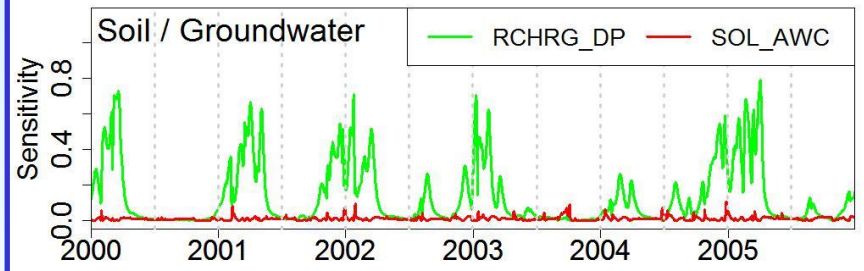
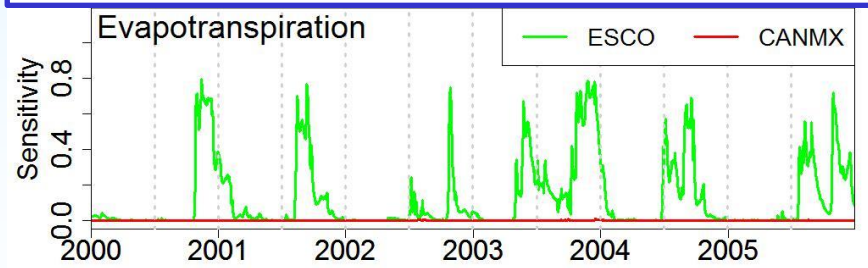
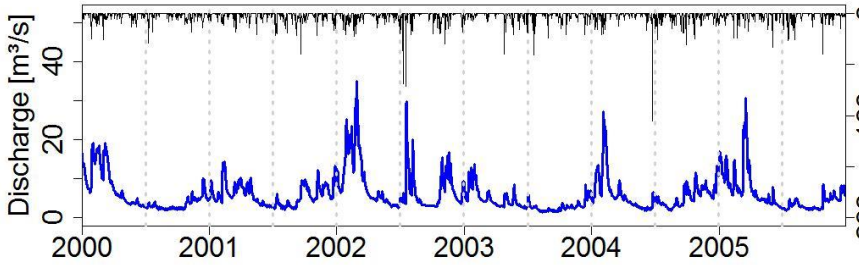
- RCHRG_DP sensitive in phases of high discharges











Guse et al. (2013, HP, in press)

Temporal dynamic of parameter sensitivity

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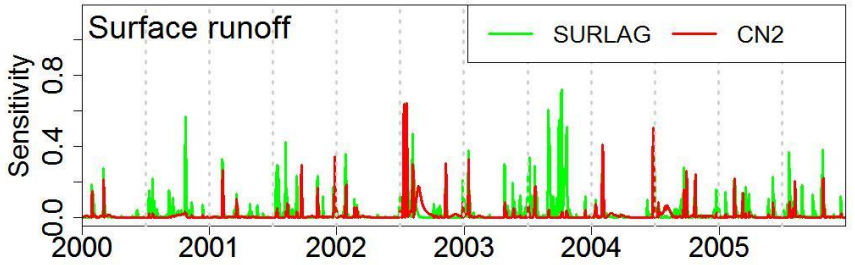
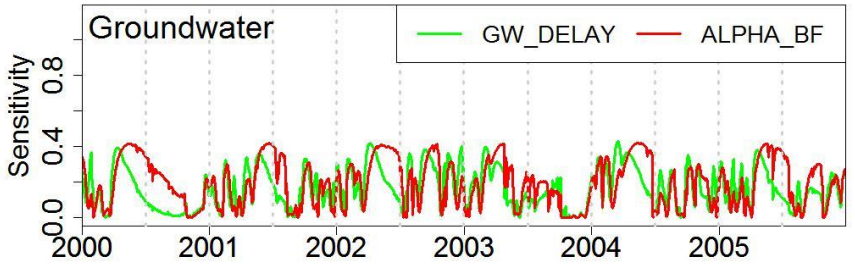
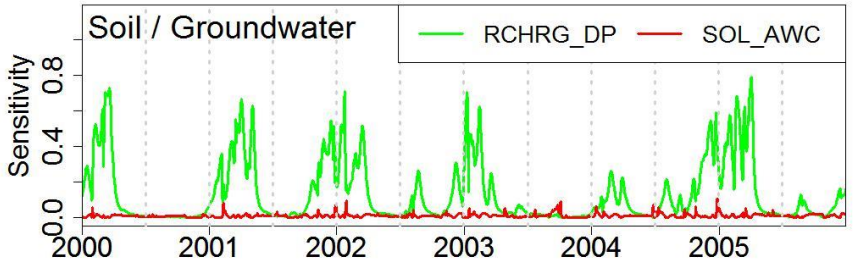
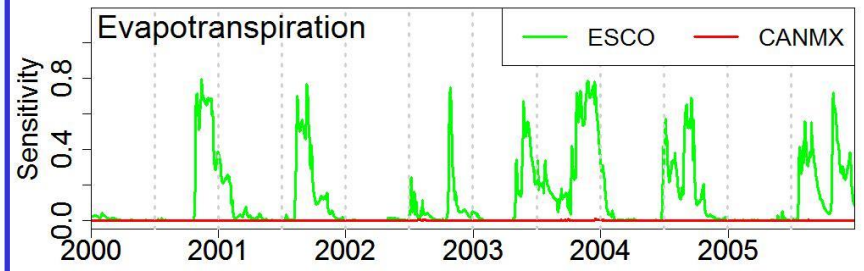
Evaporation parameter

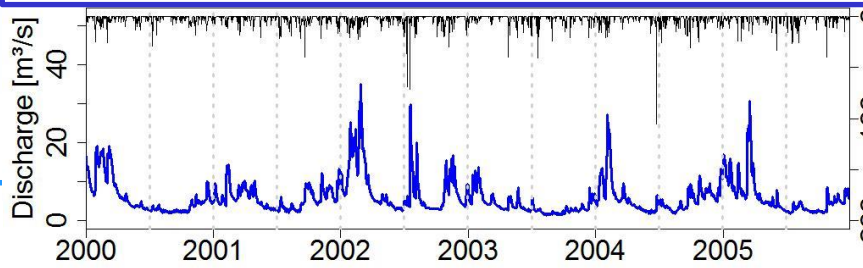
- ESCO sensitive in resaturation and baseflow period







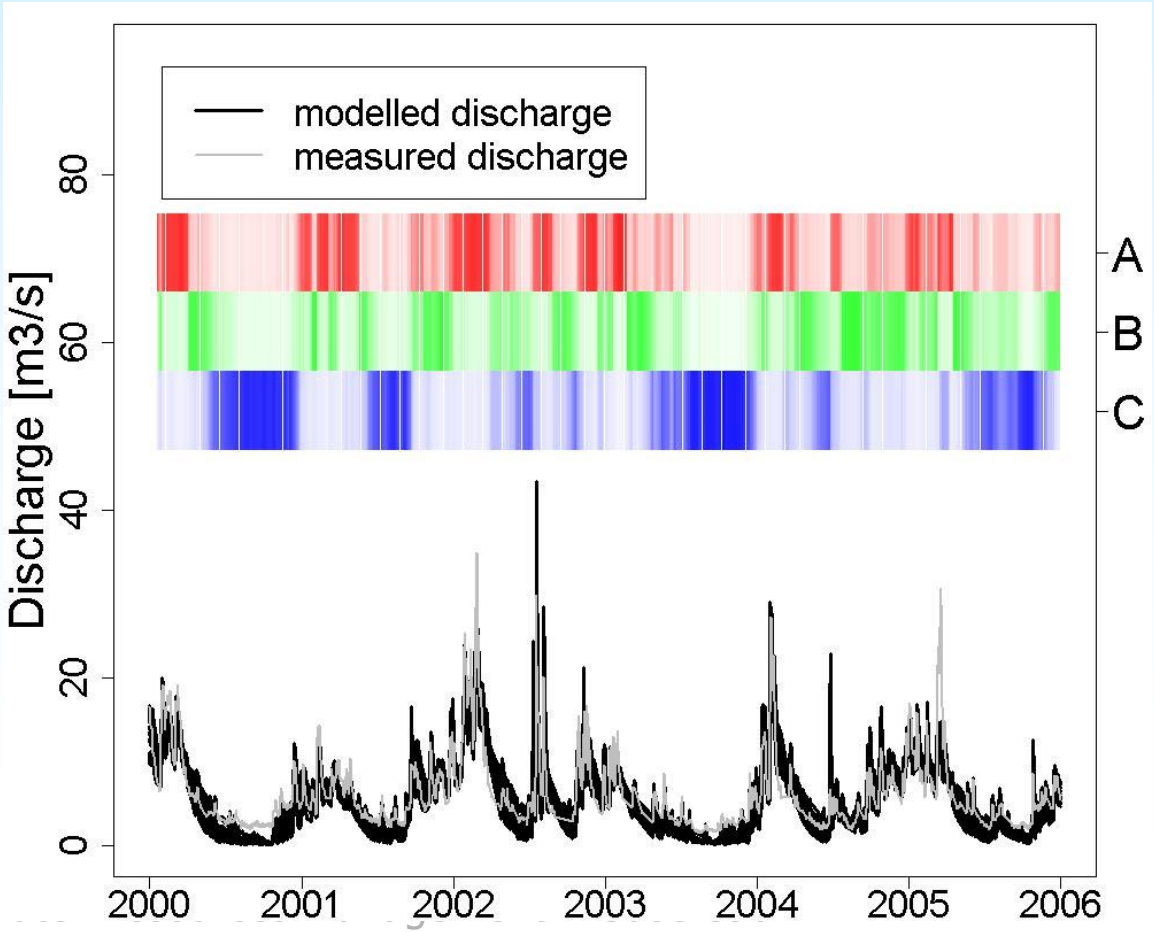




Guse et al. (2013, HP, in press)

Temporal reoccuring patterns of model performance

- Calculation of large set of performance measures for moving window of 15 days
- Classification with Self-Organising Maps (SOM) and fuzzy c-mean clustering
- Clusters characterised by values of performance measures
- Colour intensity shows contribution of each cluster
- R-package: TIGER



Reusser et al. (2009, HESS),
Guse et al. (2013, HP, in press)

Six different types of performance measures

- Three clusters characterised by values of performance measures
- Normalised performance measures in the range of 0 to 1
- Black line shows optimum value

PDIFF = peak difference

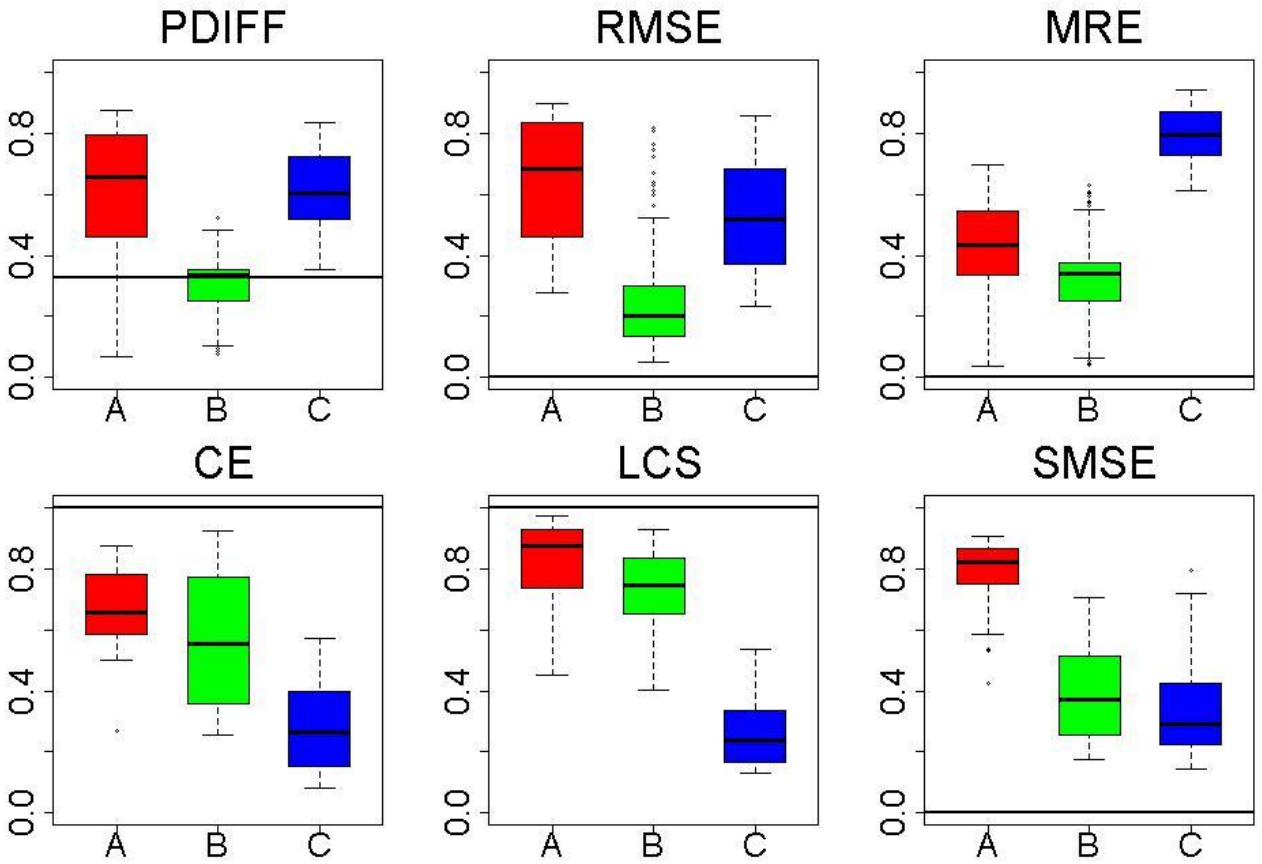
RMSE = root mean square error

MRE = mean relative error

CE = Nash-Sutcliffe

LCS = longest common sequence

SMSE = scaled mean square error



Reusser et al. (2009, HESS), Guse et al. (2013, HP, in press)

Temporal dynamic of model performance

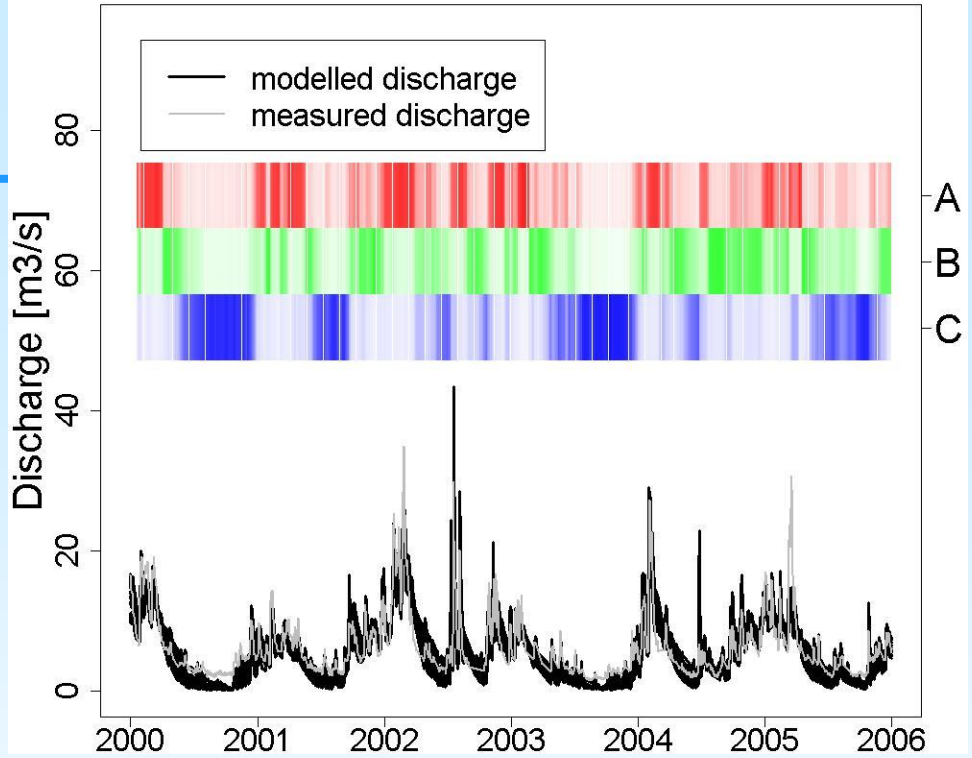
- Temporal reoccuring patterns of typical model performance

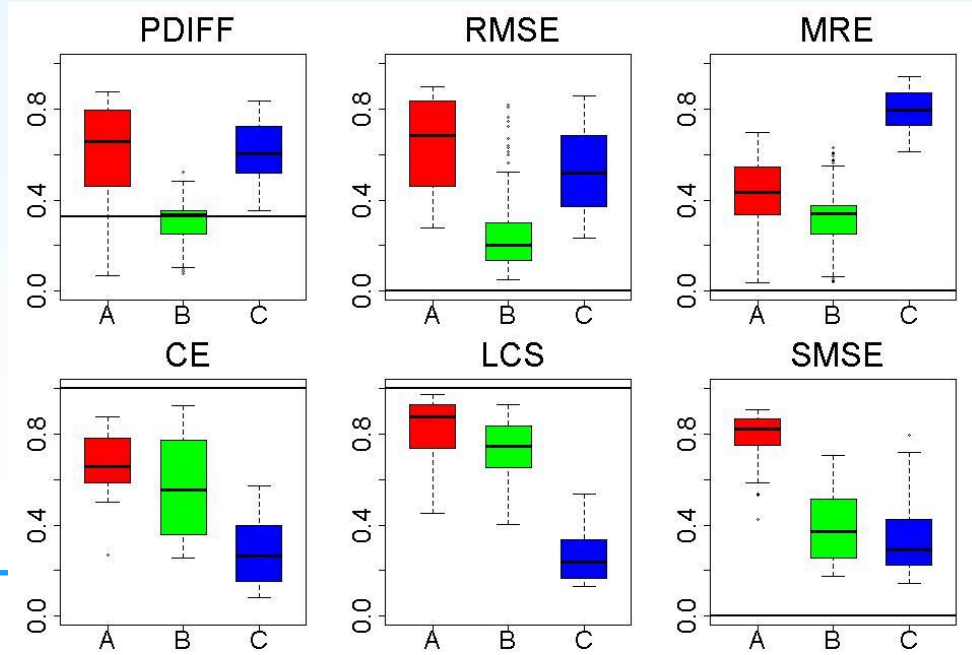
- Clusters coincide with phases of the hydrograph

  high discharges

  recession phase

  baseflow period



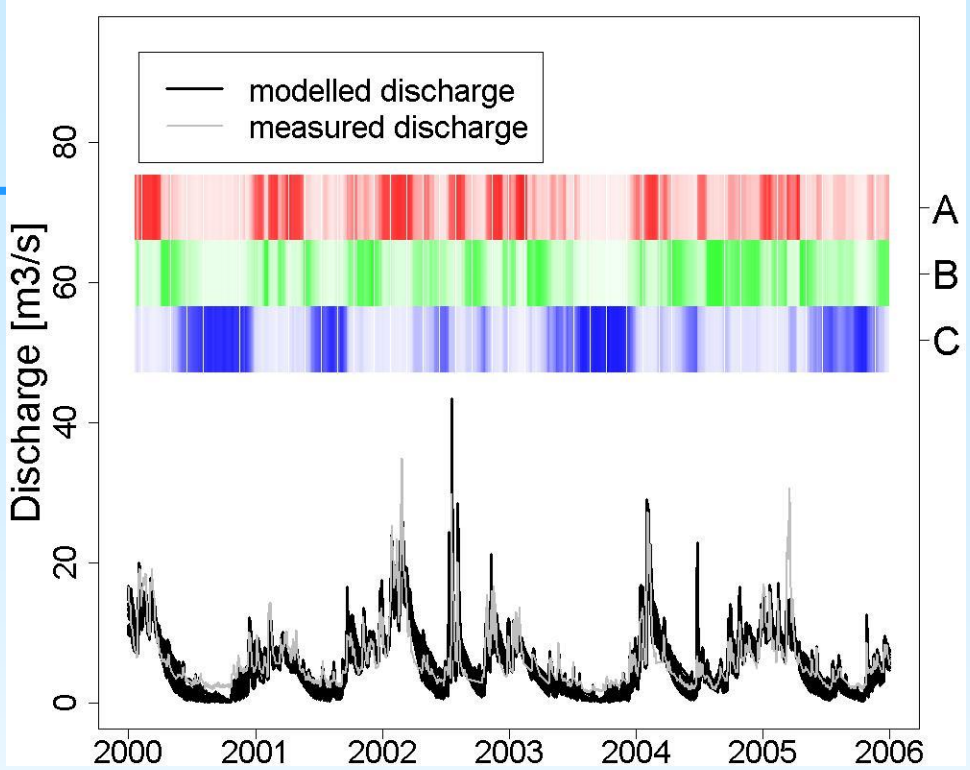


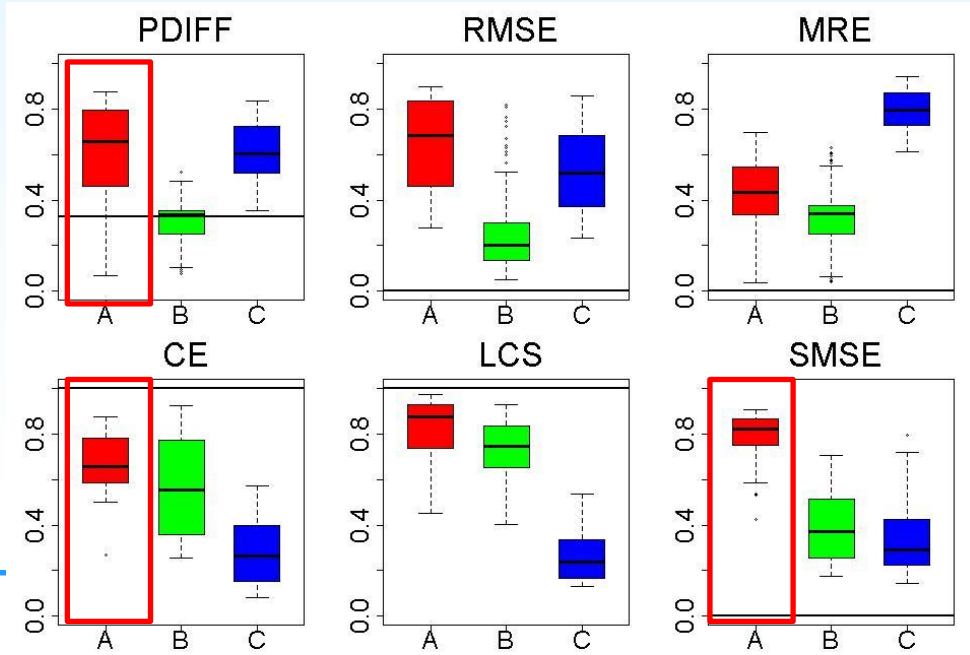
Guse et al. (2013, HP, in press)

Temporal dynamic of model performance

Cluster A (high discharges)

- Good peak performance (CE)
- Underestimation (PDIFF)
- Opposite mismatch of size of consecutive peaks (SMSE)





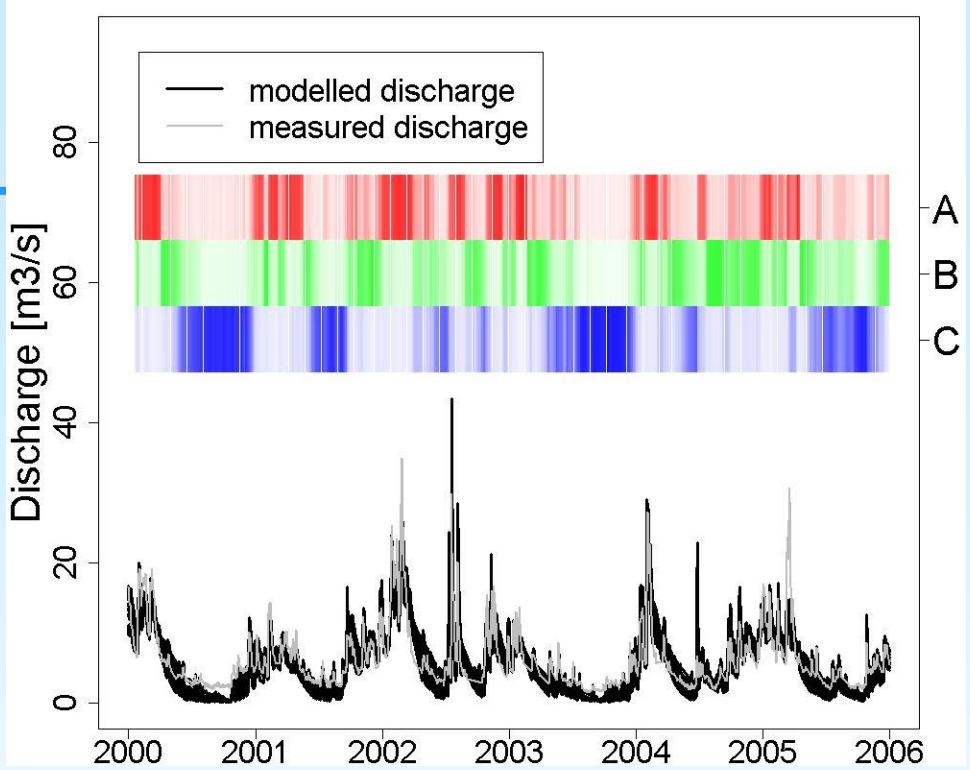
Guse et al. (2013, HP, in press)

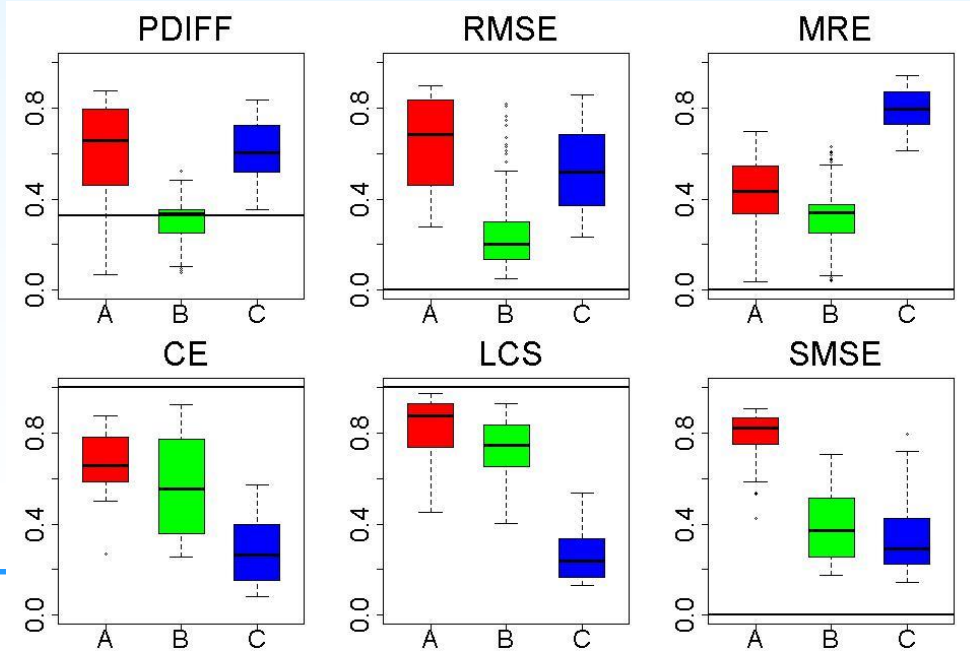
Temporal dynamic of model performance

Cluster A (high discharges)

Cluster B (recession phase)

- Overall good results for the six performance measures





Guse et al. (2013, HP, in press)

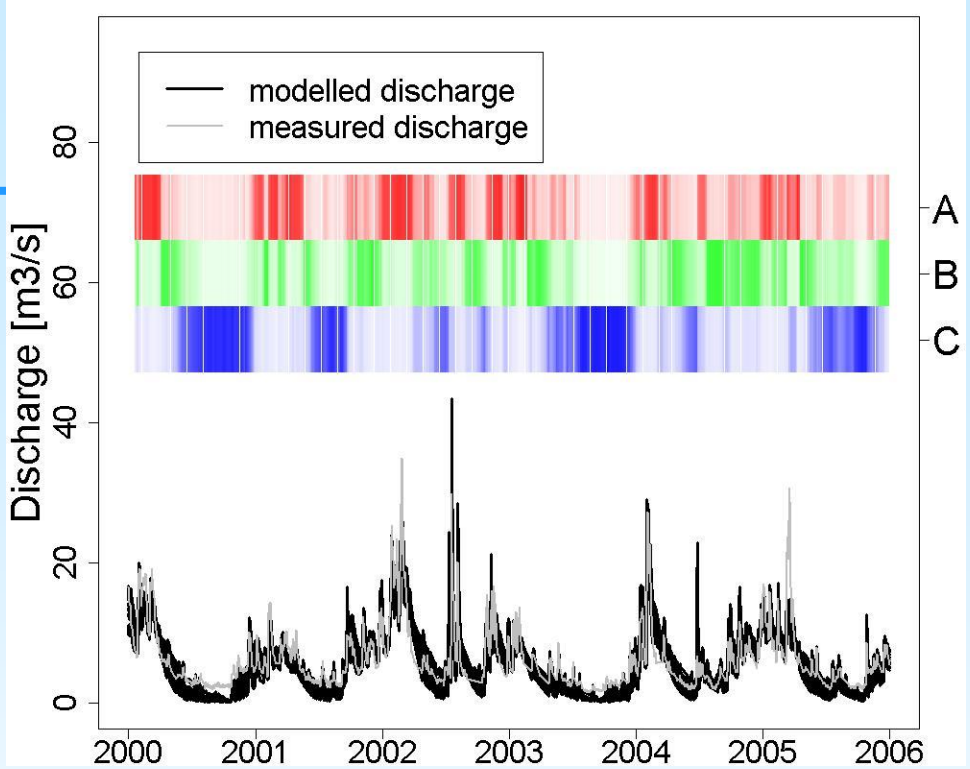
Temporal dynamic of model performance

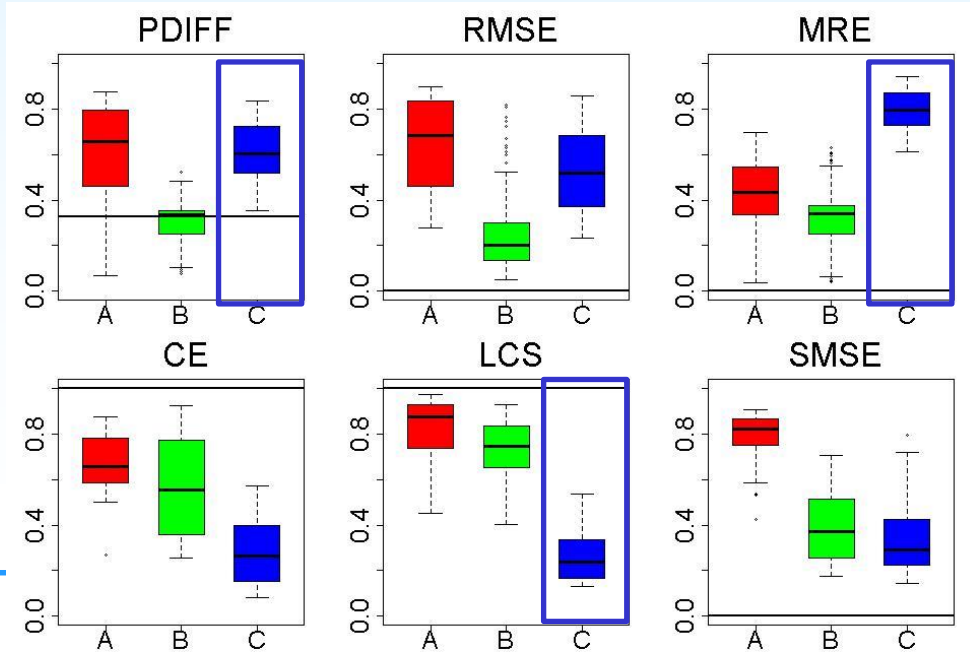
Cluster A (high discharges)

Cluster B (recession phase)

Cluster C (long dry periods + resaturation phase)

- Underestimation (PDIFF)
- Dynamics not well reproduced (LCS)
- High deviations (MRE)

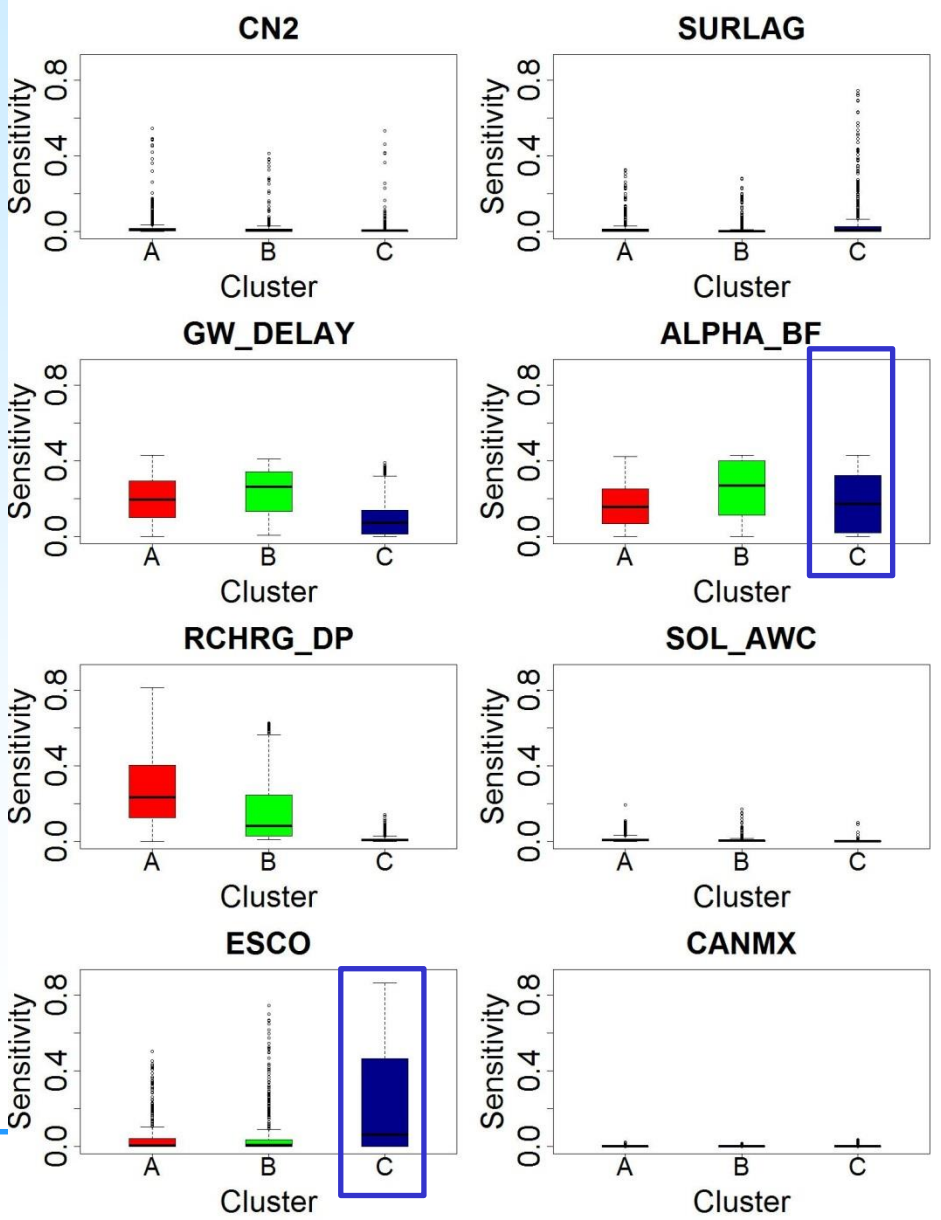




Guse et al. (2013, HP, in press)

Joined temporal diagnostic analysis

- For each cluster: Selection of all days with fuzzy membership > 0.5
- Boxplot of parameter sensitivities for these days
- Groundwater parameters dominate clusters A and B
- Cluster C with high sensitivities of ESCO and ALPHA_BF



Guse et al. (2013, HP, in press)

Discussion and conclusion

- Dominance of groundwater and evaporation parameters for the majority of the time coincides with characteristics of the Treene lowland catchment
- Six different types of performance measures give representative characteristics of model performance of three clusters
- ESCO and ALPHA_BF are dominant parameters in poor performing periods (cluster C = baseflow and resaturation phase)
- Concept of one active aquifer in SWAT is too strongly simplified for lowland catchments
- A groundwater module with more than one active aquifer is required to improve modeling with SWAT in lowlands

IMPACT

Thank you

for further information:

B. Guse, D. E. Reusser, N. Fohrer (2013): How to improve the representation of hydrological processes in SWAT for a lowland catchment – temporal analysis of parameter sensitivity and model performance**, Hydrol. Process**, in press, **doi: 10.1002/hyp.9777**

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