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

Björn Guse\textsuperscript{1,2}, Jens Kiesel\textsuperscript{3,1}, Matthias Pfannerstill\textsuperscript{1} and Nicola Fohrer\textsuperscript{1}

\textsuperscript{1}CAU Kiel  \textsuperscript{2}GFZ Potsdam  \textsuperscript{3}IGB Berlin
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

- **Treene**
  - Elevation: 80 m asl, 2 m asl
  - Location: Treia

- **Saale**
  - Elevation: 856 m asl, 415 m asl
  - Location: Blankenstein

- **Kinzig**
  - Elevation: 628 m asl, 98 m asl
  - Location: Hanau

- **Ammer**
  - Elevation: 2157 m asl, 547 m asl
  - Location: Peißenberg

**Data sources:**
- DGM Treene (LVERMA-SH)
- DAV (LAND-SH)
- DIVA-GIS (diva-gis.org)
- River network (UBA)
- SRTM 90 (Jarvis et al., 2008)
- DGM Kinzig (HVBG)
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:

![Flow duration curve segments](image)

Pfannestill et al. (2014, JH)
Methodological approach

- Latin-hypercube sampling with identical parameter sets in all catchments
- 2000 model simulations in each catchment (LH\text{Initial})
- 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 (LH\text{Constrain})
- Comparison of LH\text{Initial} with LH\text{Constrain}
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 identifiability
- low
- High

Diagram showing parameter identifiability with colors indicating different levels of identifiability.
Parameter value identification (LH_initial) - Treene

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

- Clear parameter value identification: SURLAG, LATTIME, RCHRGGssh
- 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

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

![Graph showing model performance criteria](image)
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
• Contradictory 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


