Can we parameterise Subsurface Stormflow in a conceptual simulation model using flow duration curve percentiles for calibration?

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Link to Abstract

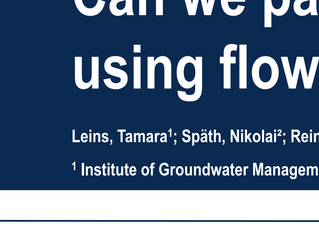
Introduction

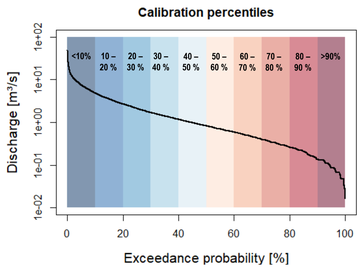
- Subsurface stormflow (SSF) describes all subsurface flow that reaches the stream during an event. It can be an important element at the catchment scale flood generation.
- The identification of SSF parameters in hydrological models is a difficult task and is often affected by equifinality.
- There is a lack of data and systematic studies on SSF.

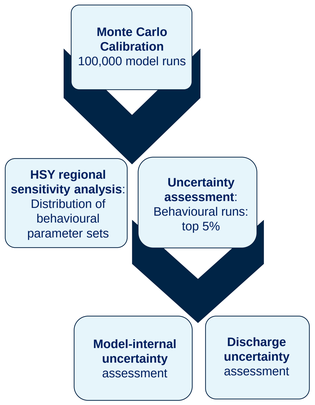
- DFG-funded Research Unit (RU) "**FOR 5288: Fast & Invisible – Conquering Subsurface Stormflow through an Interdisciplinary Multi-Site Approach**":
  - 9 Institutes, 4 catchments, 7 scientific projects
  - Comprehensive Study on SSF
  - Intensive instrumentation for SSF quantification

Methods

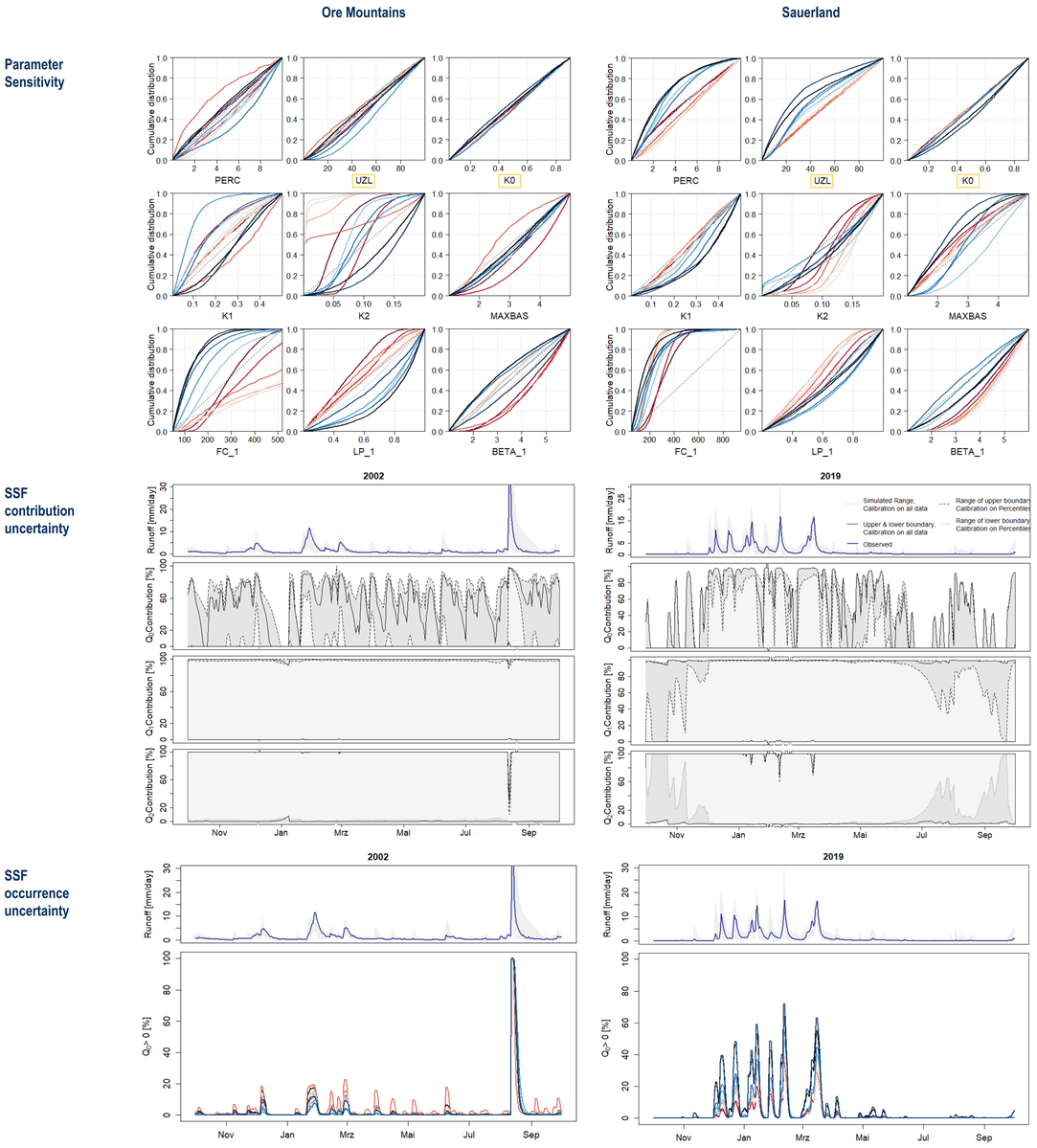
In order to assess whether we can gain more information about SSF from different parts of the flow duration curve (FDC), we performed our calibration and analysis based on all available discharge data as well as based on different percentiles of the FDC. We did this using the widely-used HBV-light model (Bergström, 1992; Seibert & Vis, 2012) with fixed snow parameters (Beck et al., 2020), where one model-internal flow (Q_0) conceptually represents SSF. We then compared the resulting differences on the basis of three metrics: parameter sensitivity (Hornberger and Spear 1981), simulated SSF contributions to total discharge and simulated SSF occurrence.





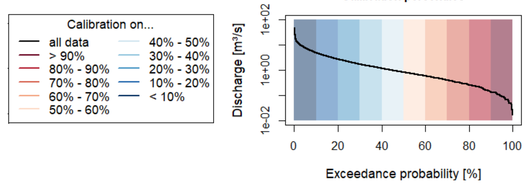


Results



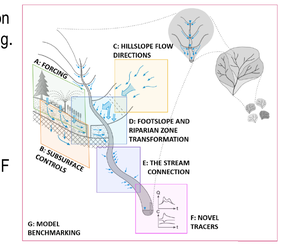
- In general, the model-internal flows show high uncertainties. For SSF, the simulated volume (contribution) as well as the occurrence varies greatly between the behavioural model runs.
- On the other hand, the timing of SSF is more precise: If behavioural runs agree that SSF occurs, the timing mostly coincides.
- SSF occurrence becomes more likely with higher discharge and at very high discharge, occurrence uncertainty is greatly reduced. However, SSF contributions stay highly uncertain.
- By calibration on different FDC percentiles, contribution uncertainties can be slightly reduced. For instance, for the Sauerland catchment, the mean width of SSF contribution uncertainty bands is 63±37 % for calibration on all data. It can be reduced to a minimum of 44±36 % when calibrated on the 20-30 % FDC percentile.
- SSF parameters generally show low sensitivity. For the Sauerland catchment, the sensitivity of SSF parameter UZL can be slightly increased by calibration on the <10 % FDC percentile.

Legend



Conclusions and Outlook

- Could we gain more information on SSF by using the FDC percentiles for calibration?
  - While there are some indications for it, where SSF contribution and occurrence uncertainty are slightly reduced, the identifiability of SSF stays limited.
  - We need additional data on SSF to get gain more information on its occurrence and volume and to make its parameters more identifiable.
- Up next: Multi-objective calibration using newly derived SSF data, e.g.
  - Trench flow data – SSF occurrence
  - Water chemistry data, tracer data – hydrograph separation, SSF contribution



Chifflard et al. (2023)

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