Towards a robust parameterization of subsurface stormflow in hydrological models at the catchment scale

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Link to Abstract

This presentation participates in OSPP – Outstanding Student & PhD candidate Presentation contest

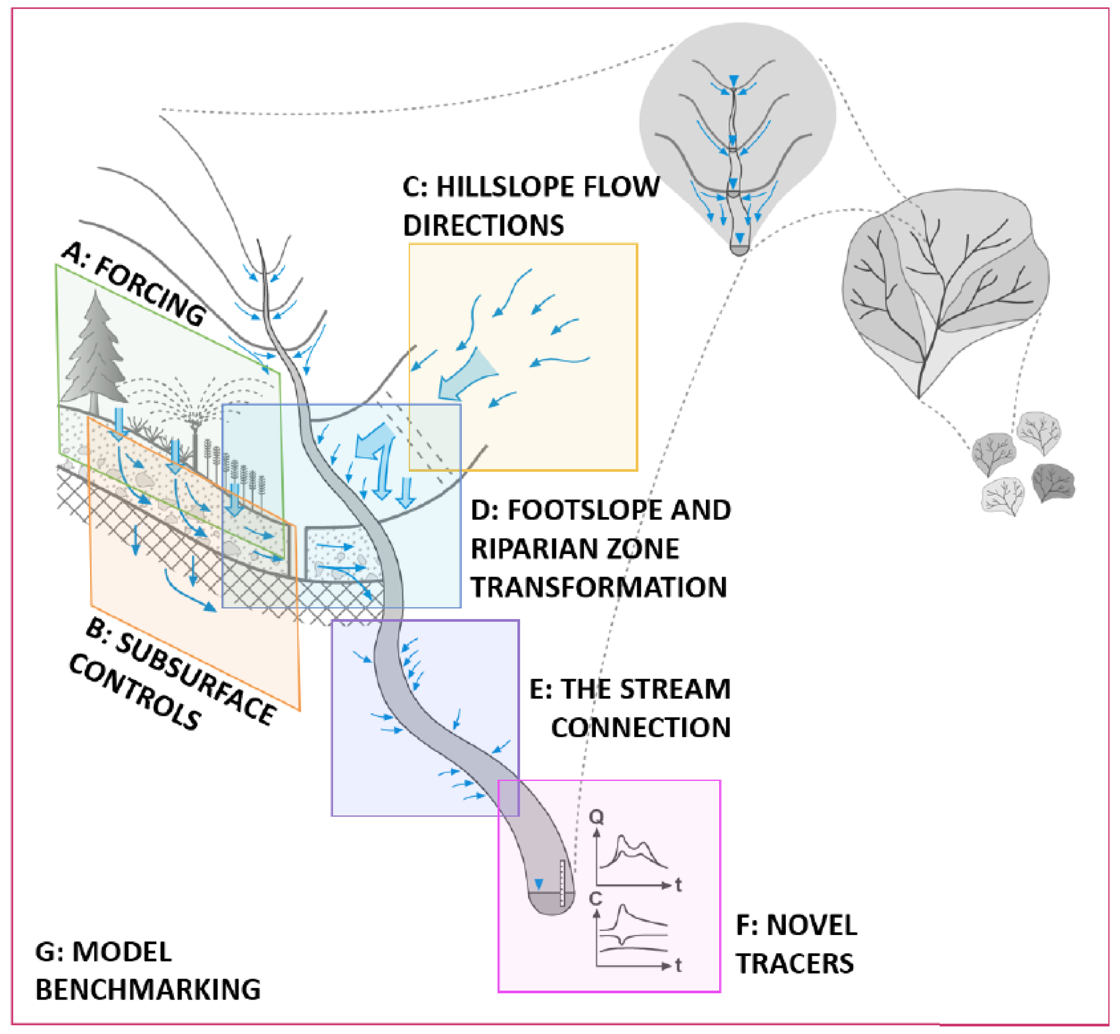
INTRODUCTION

- Subsurface stormflow (SSF) is a runoff produced in upland terrains when hydraulic lateral conductivity is greater than vertical conductivity. It describes all subsurface flow that reaches the stream during an event.
- SSF can be a very important element at the catchment scale flood generation as well as in nutrient and contaminant transport.
- Intensive instrumentation is required to quantify SSF due to its invisibility and spatial heterogeneity.
- There is a lack of systematic studies on SSF.

Hartmann (2016)

FRAMEWORK - RESEARCH UNIT

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 (A - G)



Chifflard et al. (2023)

Intensive instrumentation for SSF quantification

Our subproject G will compile and use data on SSF initiation and flow rates collected by other subprojects, e.g.
- Direct observations from trenched hillslopes
- Indirect SSF-related observations from piezometers

OVERALL OBJECTIVES OF THE RU

Thorough and systematic investigation of SSF by:

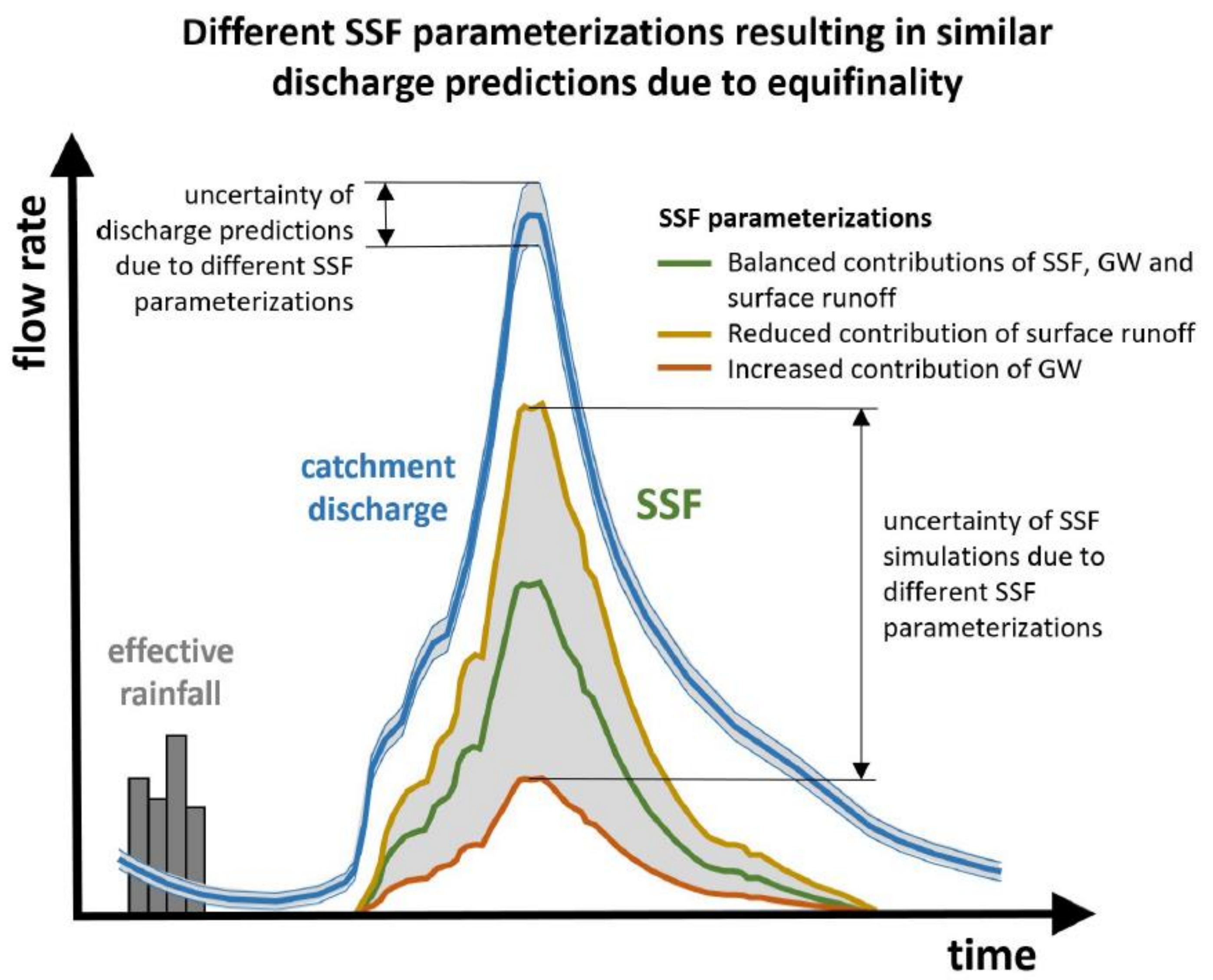
- Development of novel experimental designs and methodologies
- Working across scales and sites
- Identification, characterization, and prediction of:
  spatial patterns, thresholds, cascading effects and impacts of SSF

STUDY SITES

The four study sites in the Sauerland, the Black Forest, the Ore Mountains and the Alps cover different hillslope gradients as well as climatic and hydrological characteristics.

MOTIVATION

- Calibration of hydrological models is often only based on observations of total discharge at the catchment outflow.
- Observations of total discharge only contain limited information.
  - Uncertain distinction of model internal lateral flow paths (e.g. SSF)
  - High chance of equifinality of parameters and processes
  - Increase in overall model uncertainty



- Due to a lack of understanding and observations of SSF, realistic simulation of SSF has only been targeted by very few modelling studies.
- So far, there has not been a systematic benchmarking of SSF routines in hydrological models.

OBJECTIVES

SSF Model Benchmarking
Benchmarking of existing SSF approaches in catchment scale lumped hydrological models

Multi-Objective Calibration
Achieve an improved and robust SSF parameter estimation by the integration of proxy data in a multi-objective calibration

Model Application
Exploration of larger time-scales and extreme conditions

MODEL BENCHMARKING

- Wide range of SSF simulation concepts
- Missing systematic evaluation

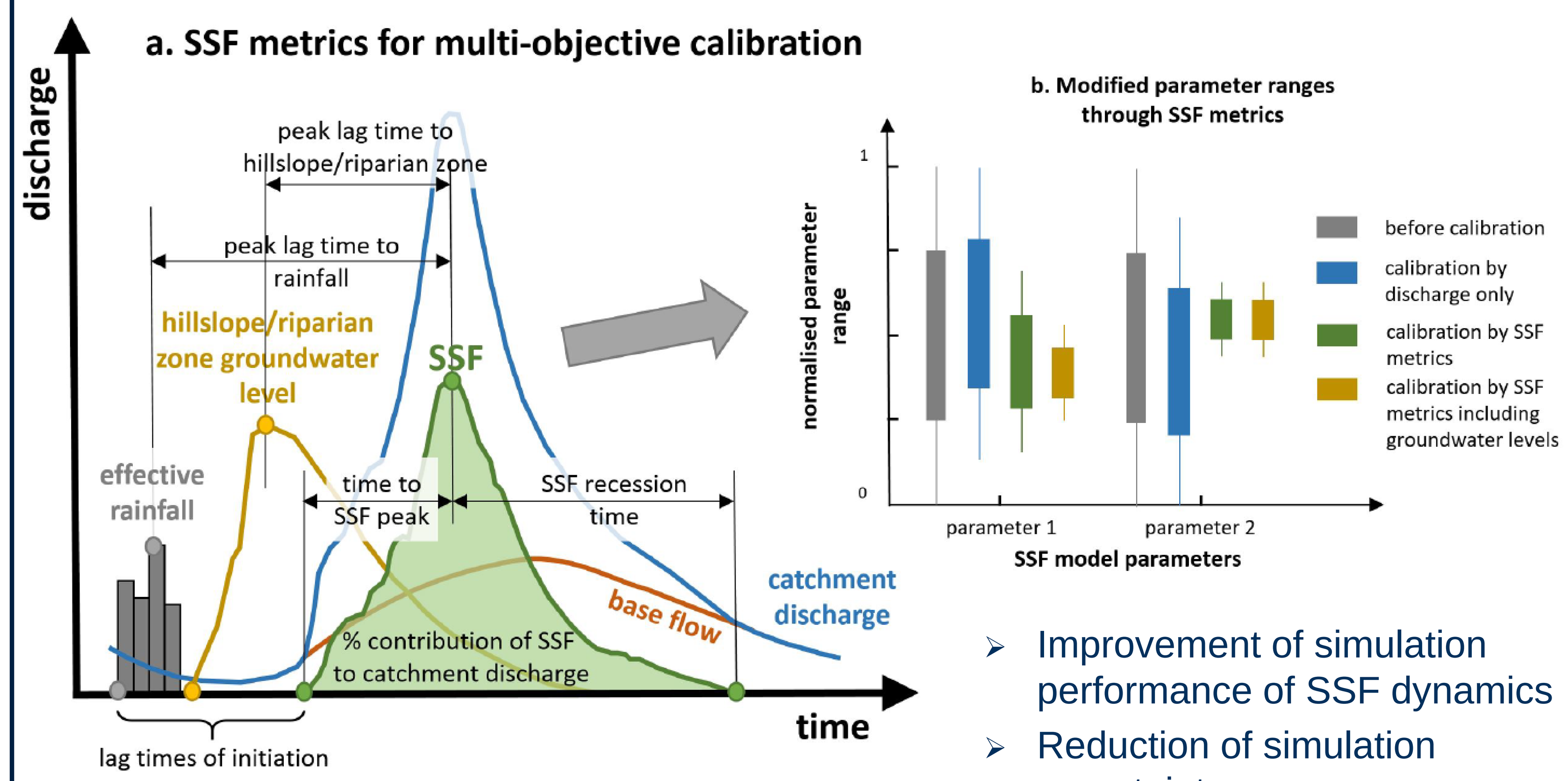
→ Show & quantify differences in SSF simulations and SSF simulation uncertainty

- Using only basic data (e.g. soil maps) and stream flow data for model calibration
- Application of a consistent sensitivity analysis framework
- Selection of existing modelling systems, examples for lumped models:

Model	SSF Simulation Approach
HBV	Linear storage activated when shallow groundwater storage exceeds threshold
Topmodel	Storage based on soil topographic index and local transmissivity

MULTI-OBJECTIVE CALIBRATION

- Inclusion of newly collected SSF proxy data in model calibration
- Development of SSF metrics to iteratively include SSF proxies



- Improvement of simulation performance of SSF dynamics
- Reduction of simulation uncertainty

MODEL APPLICATION

- Transfer, optimized designs, generalization, and catchment inter-comparison
- Identification of the most reliable SSF simulations (models & proxies)
- Exploration of SSF dynamics on larger time-scales
- Analysis of the impact of extreme weather conditions on SSF occurrences and volumes
- Exploration of relationships between simulated SSF responses to simulated and observed catchment storage

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Sharing is encouraged

REFFERENCES

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