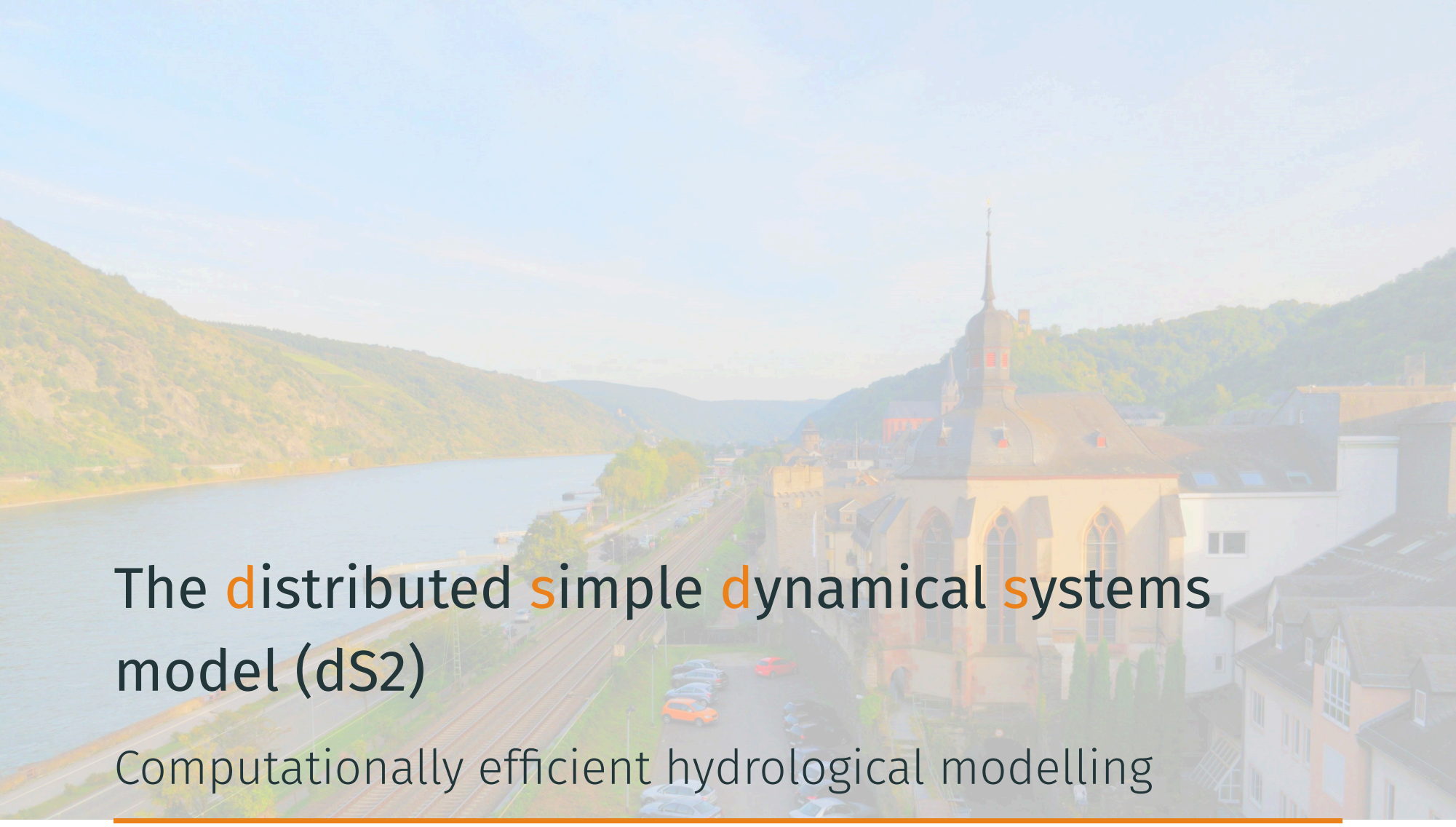

The distributed simple dynamical systems model (dS2)

Computationally efficient hydrological modelling

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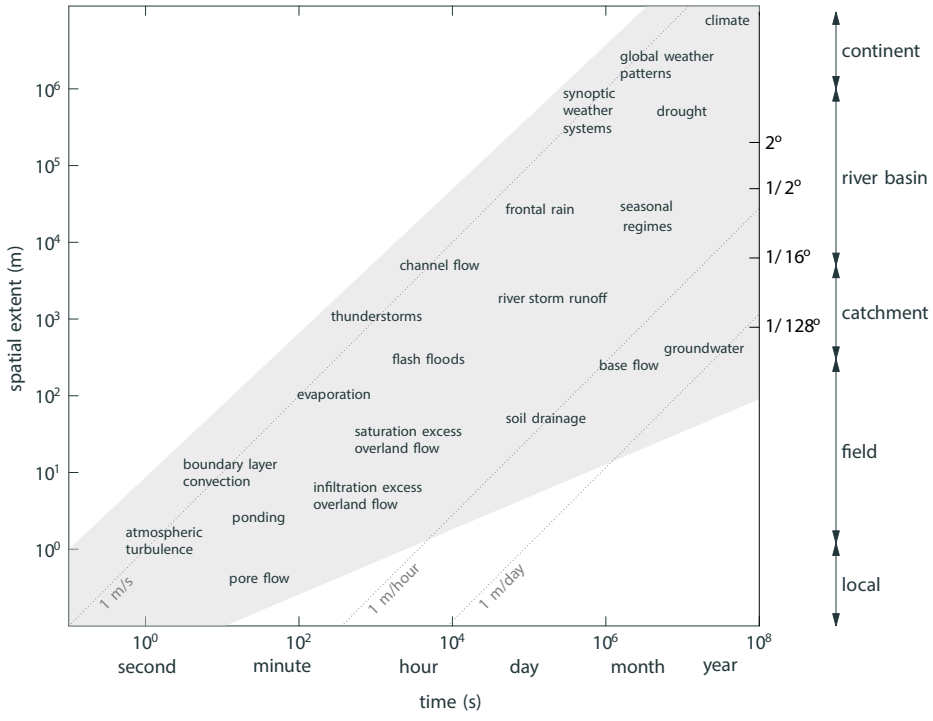
WAGENINGEN
UNIVERSITY & RESEARCH

Motivation

Increasing computational power

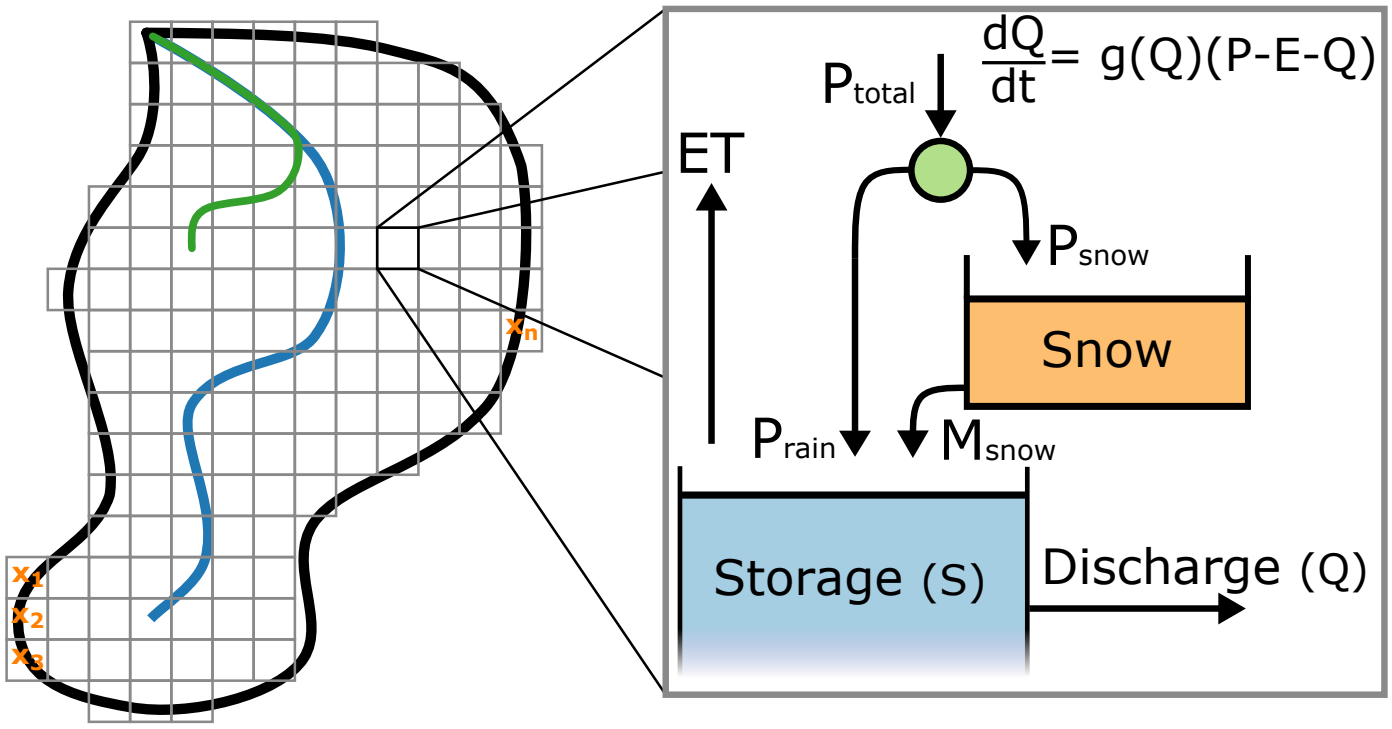
- Higher spatial resolutions vs temporal resolution
- Computational efficiency?

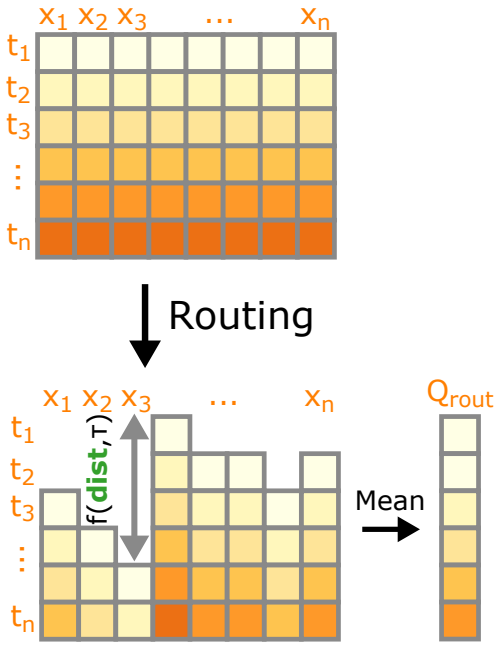
“Bucket”-based models



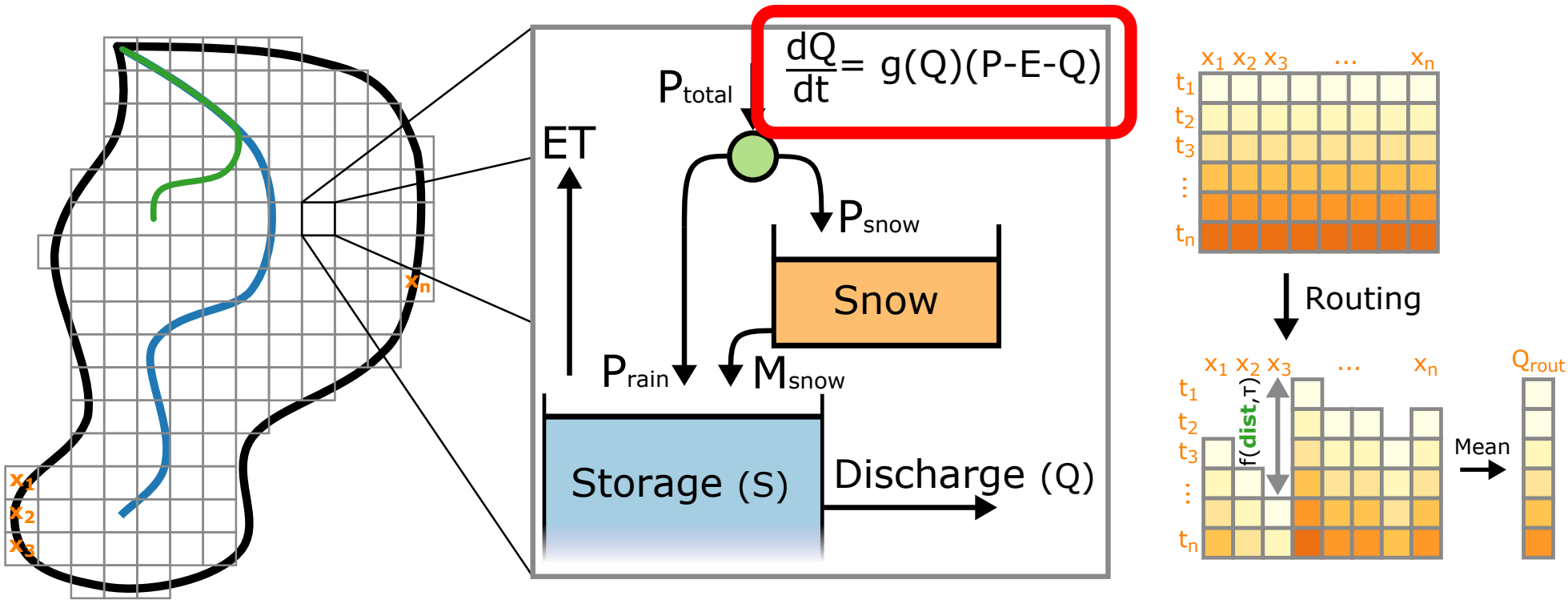
Melsen, L. A., Teuling, A. J., Torfs, P. J. J. F., Uijlenhoet, R., Mizukami, N., and Clark, M. P.: HESS Opinions: The need for process-based evaluation of large-domain hyper-resolution models, *Hydrol. Earth Syst. Sci.*, 20, 1069-1079, https://doi.org/10.5194/hess-20-1069-2016, 2016.

dS2 in a single picture

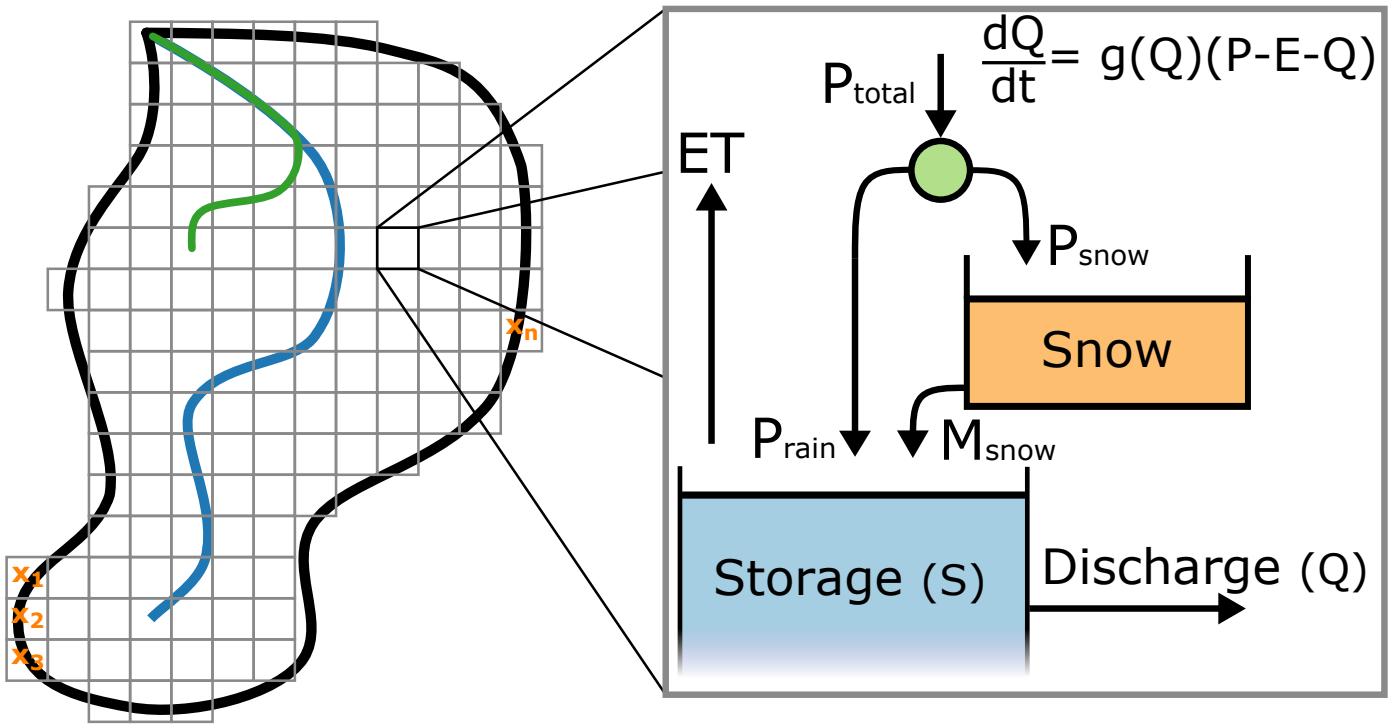


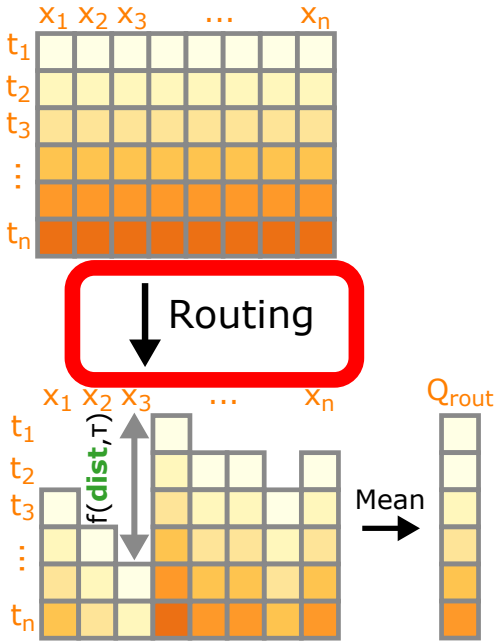


dS2 in a single picture



dS2 in a single picture





Discharge sensitivity

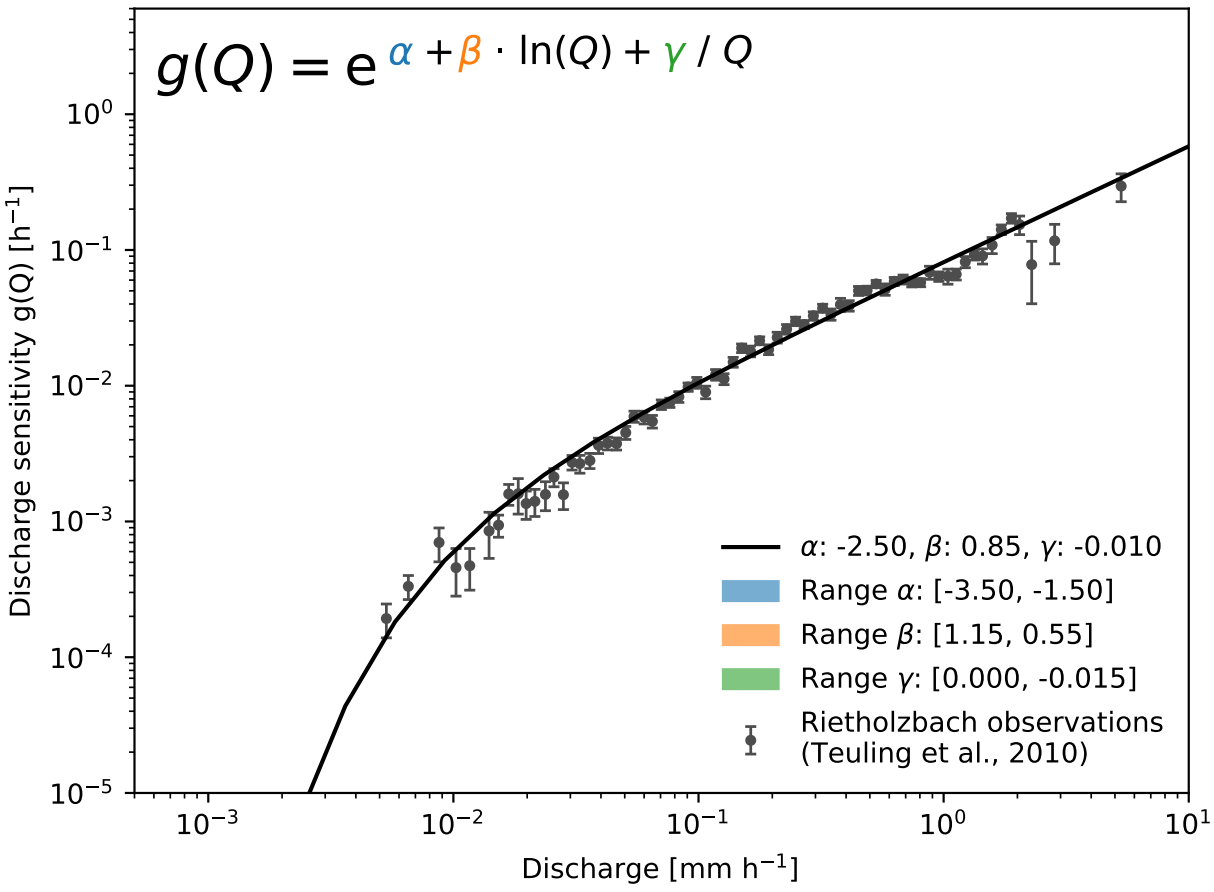
$$\frac{\mathrm{d}S}{\mathrm{d}t} = P - E - Q$$

$$Q = f(S)$$

$$\frac{\mathrm{d}Q}{\mathrm{d}t} = \frac{\mathrm{d}Q}{\mathrm{d}S} \cdot \frac{\mathrm{d}S}{\mathrm{d}t}$$

$$= \frac{\mathrm{d}Q}{\mathrm{d}S}(P - E - Q)$$

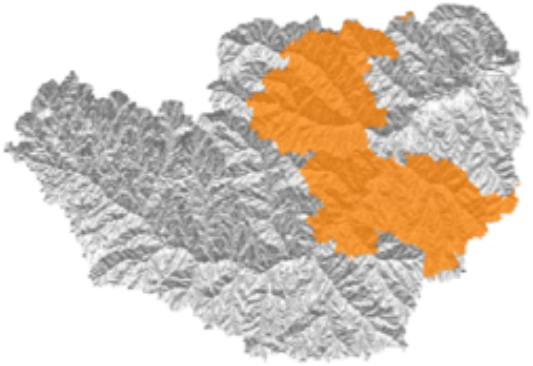
$$\frac{\mathrm{d}Q}{\mathrm{d}t} = g(Q)(P - E - Q)$$



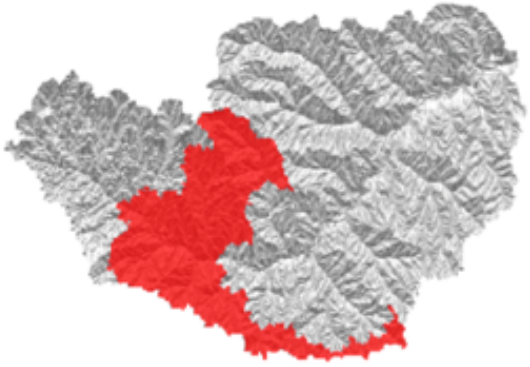
Routing - width function

Sub-basin 1: d <10 Km

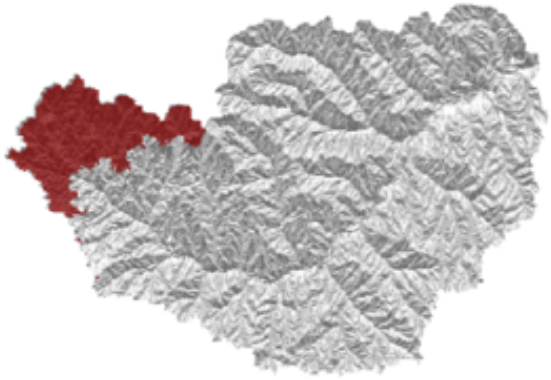
Sub-basin 2: 15 <d< 25 Km



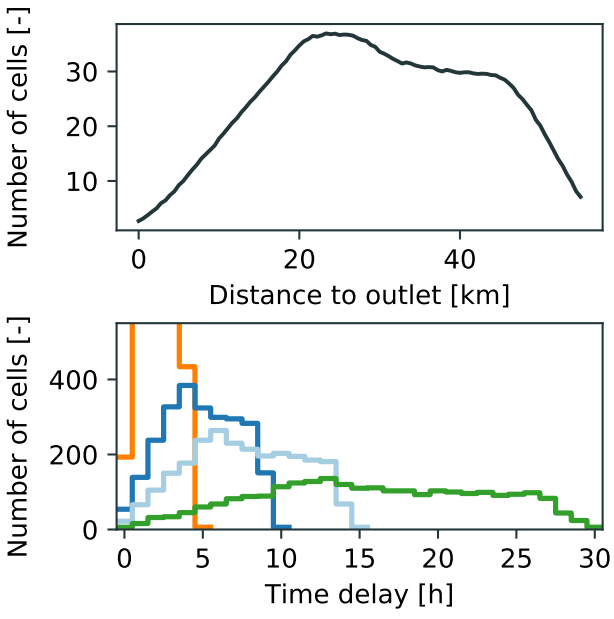
Sub-basin 3: 35 <d< 45 Km

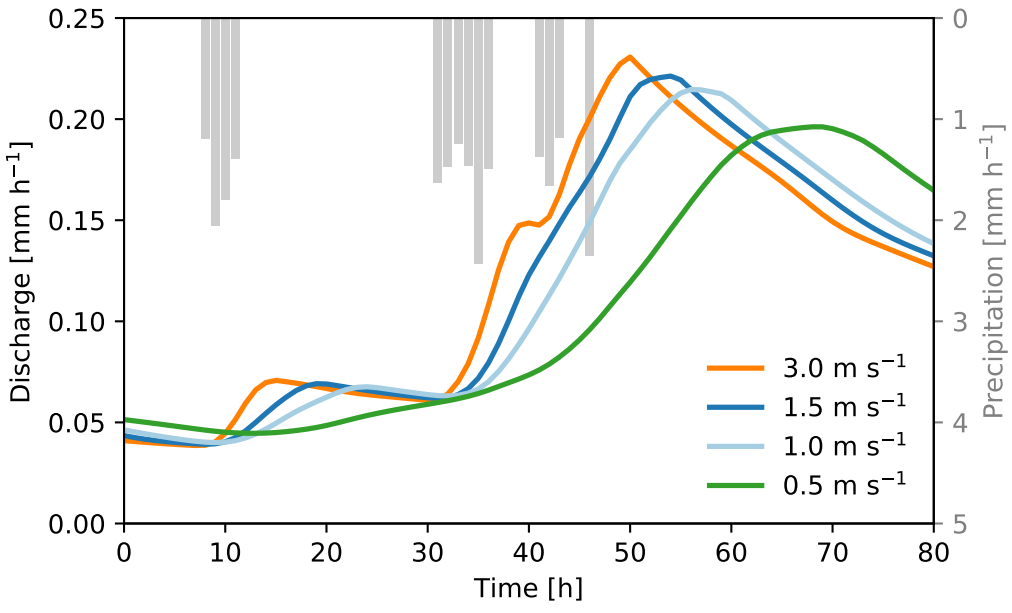


Sub-basin 3: 60<d< 60 Km



Routing - width function



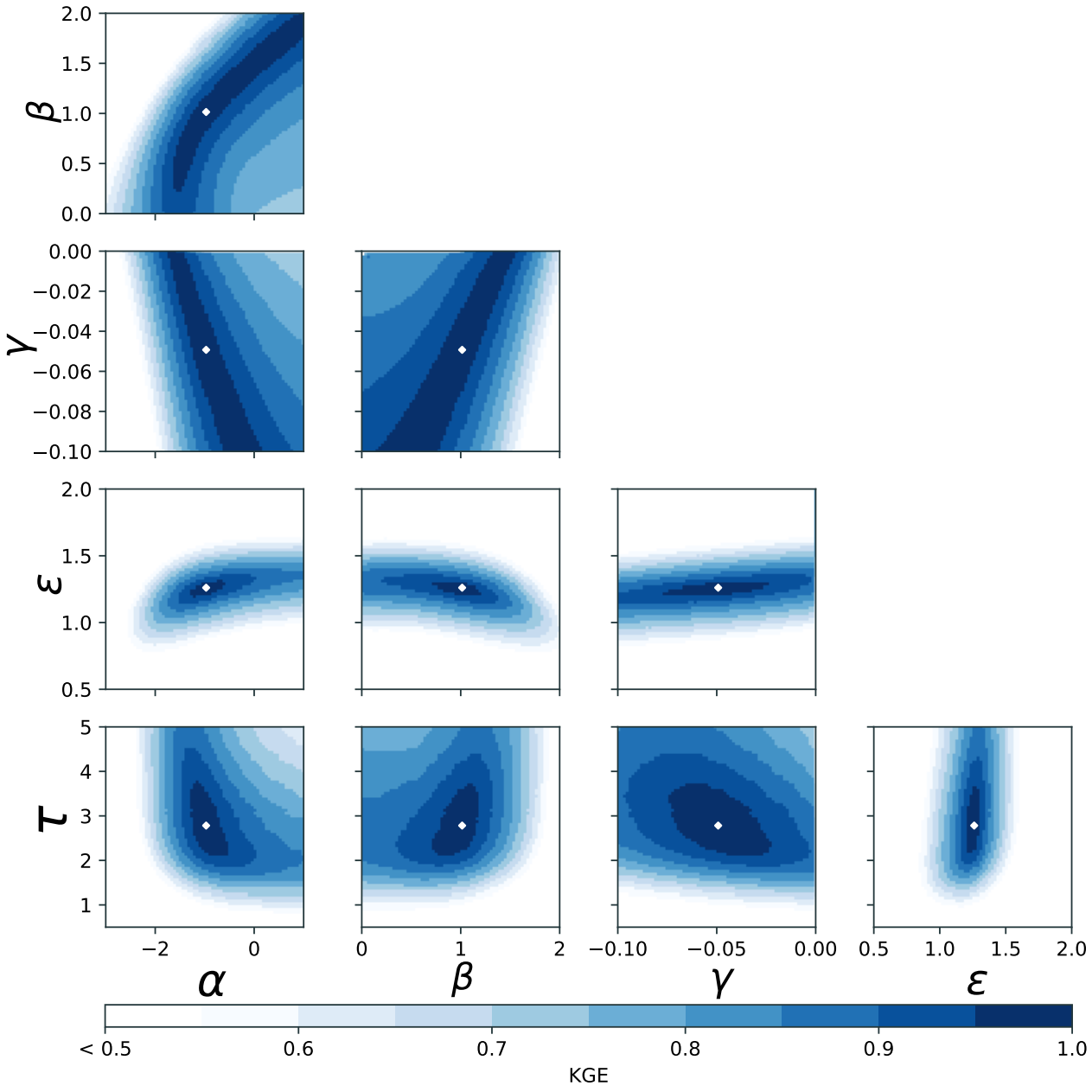


Model runtimes

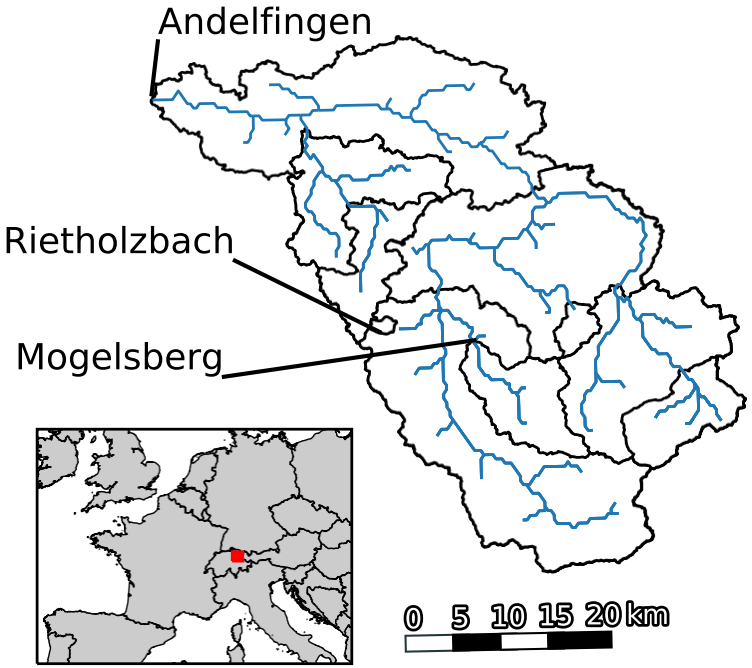
All runtimes are with hourly timestep

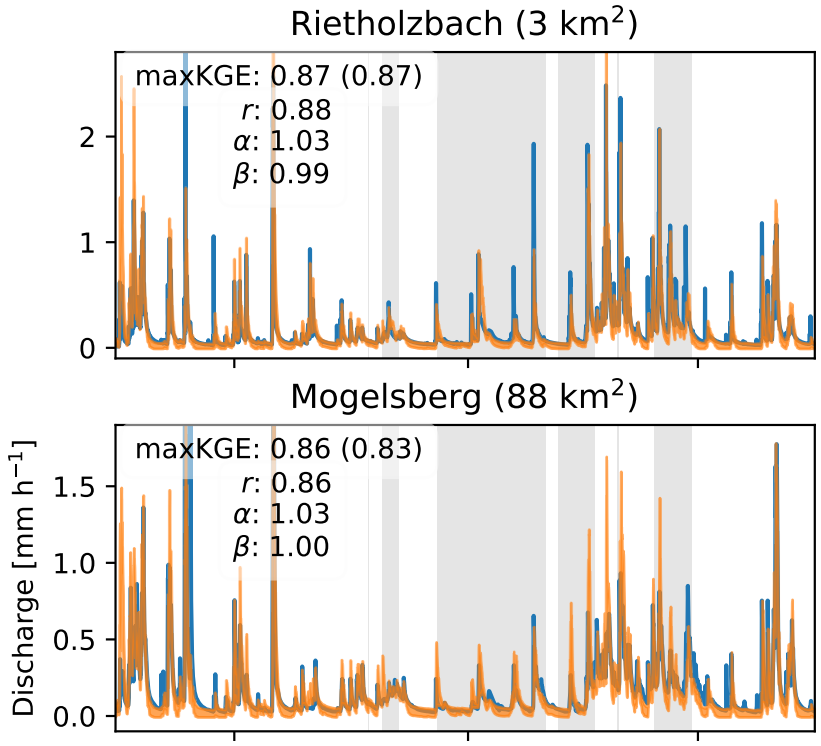
Area	Resolution	Period	Runtime
Thur ($1\,700\ \mathrm{km}^2$)	$1 \times 1\ \mathrm{km}^2$	1 year	3 seconds
Rhine ($185\,000\ \mathrm{km}^2$)	$\pm 4 \times 5\ \mathrm{km}^2$	1 year	10 seconds
Europe ($10 \cdot 10^6\ \mathrm{km}^2$)	$5 \times 5\ \mathrm{km}^2$	3 months	6 minutes

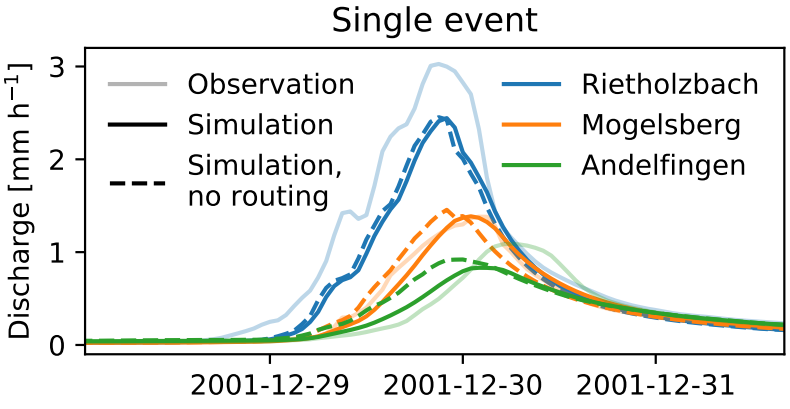
Parameter sensitivity



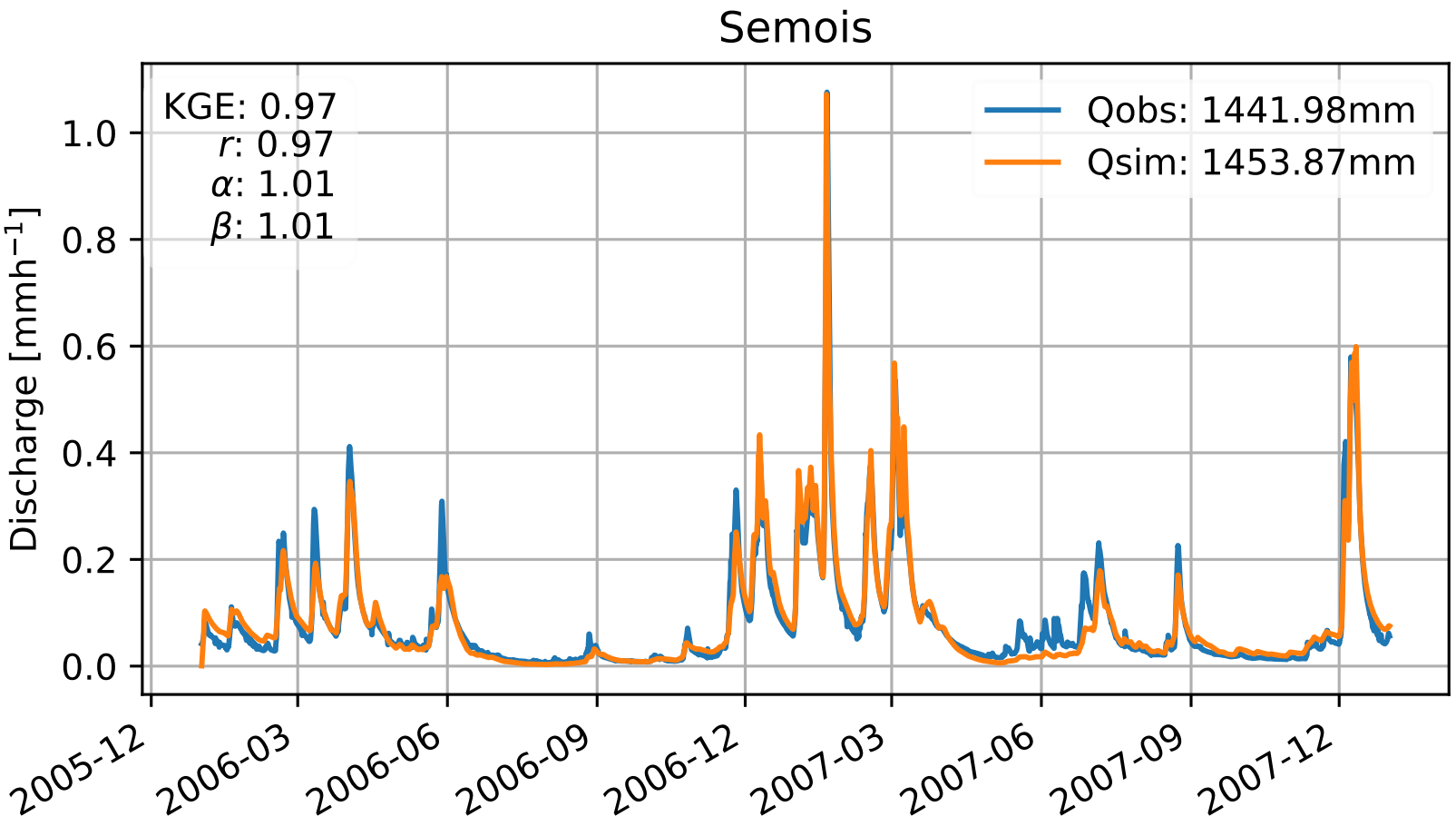
Results Thur



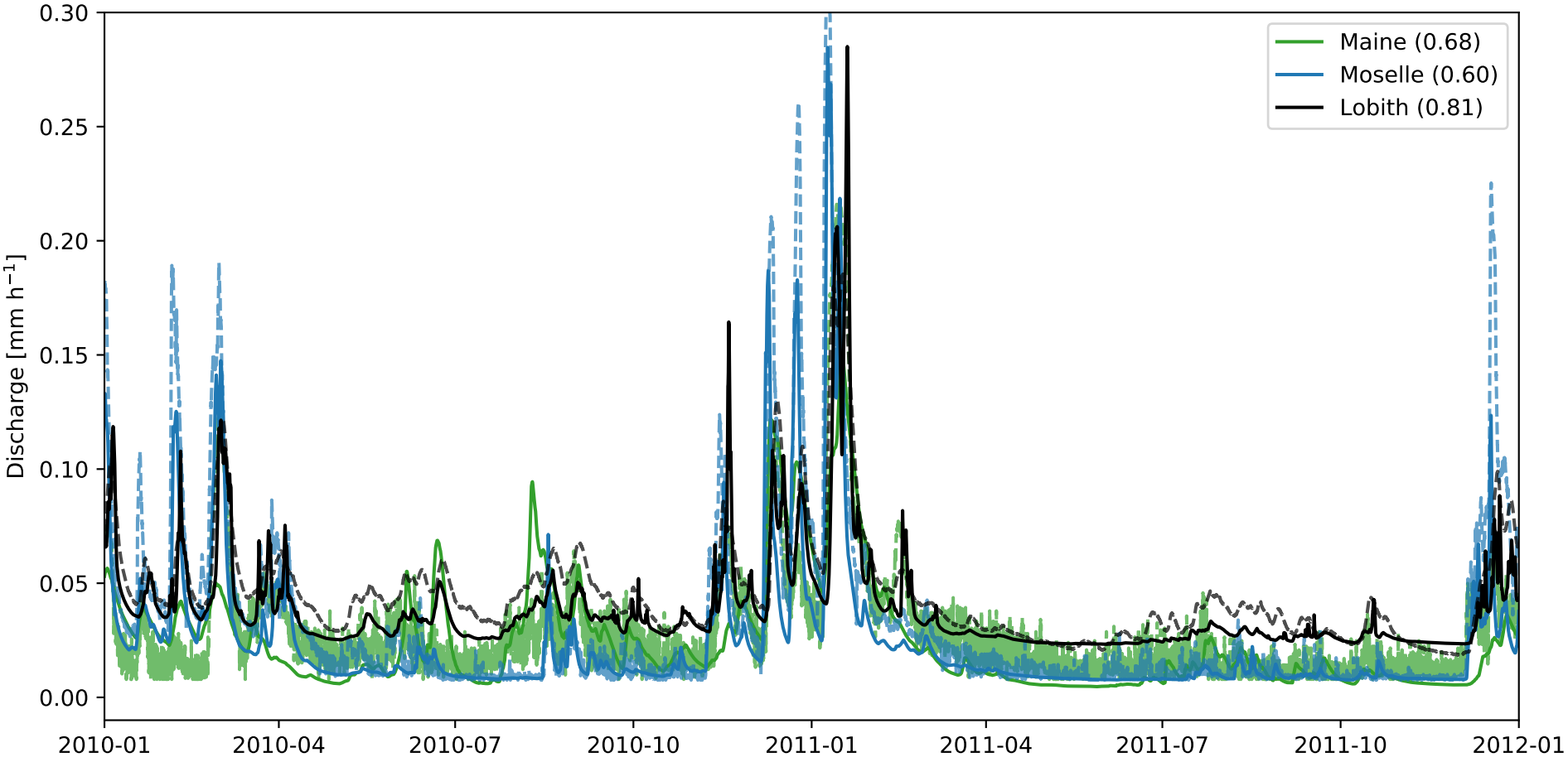




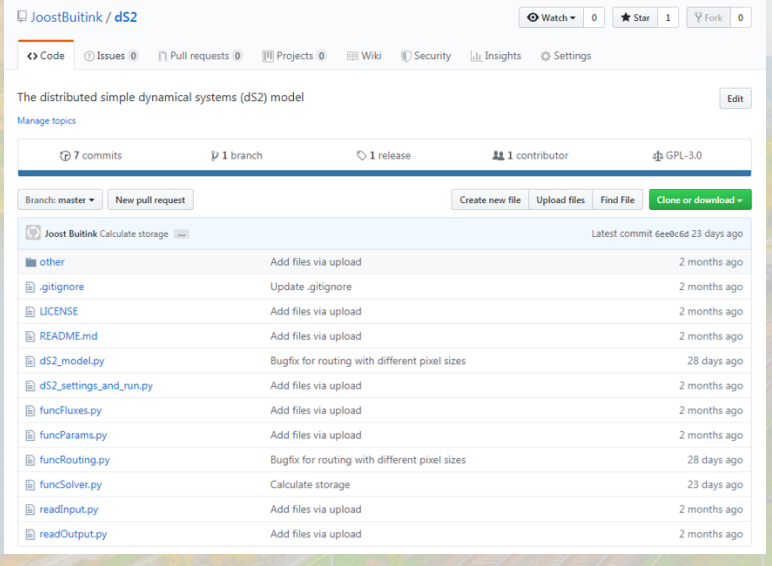
Results Meuse



Results Rhine



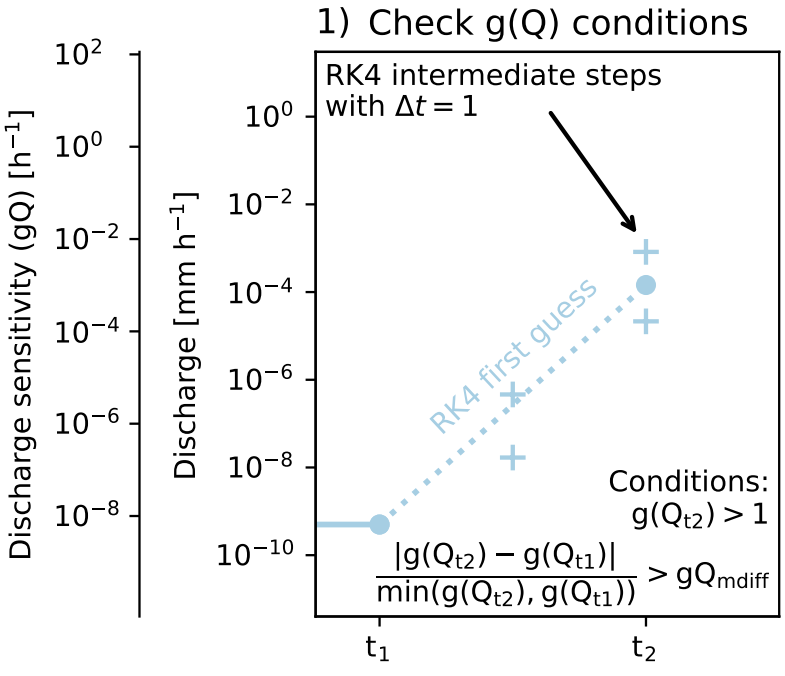
Questions?



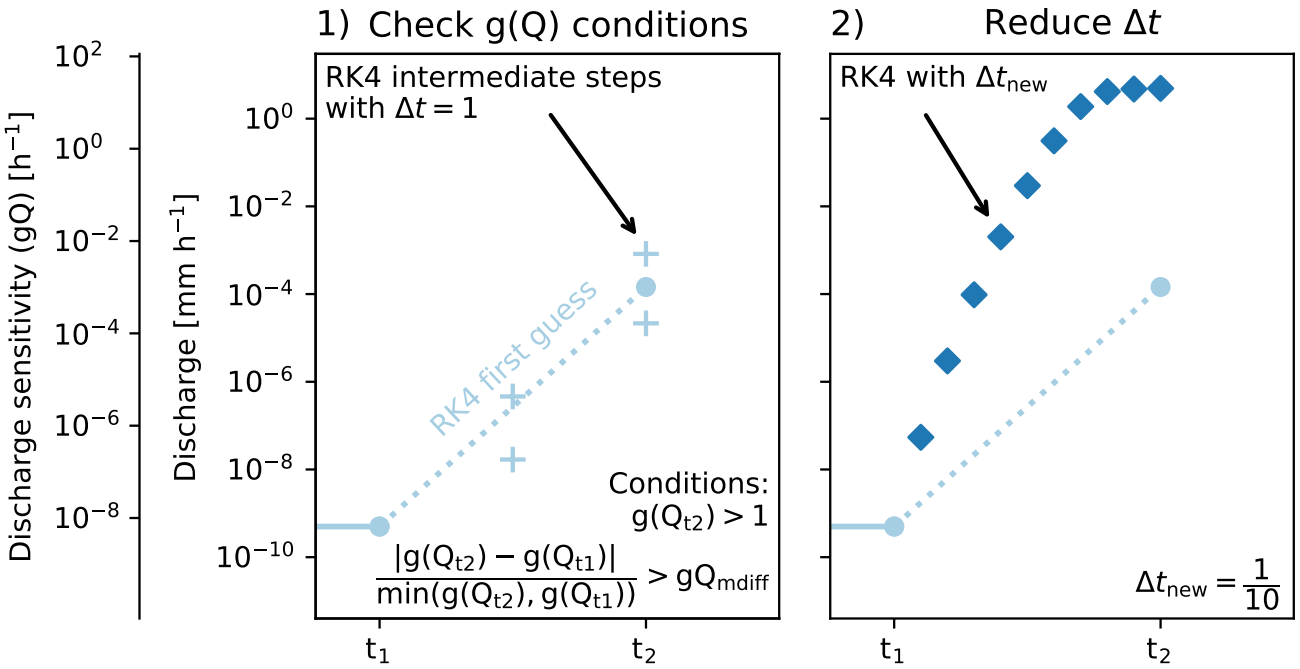
https://github.com/JoostBuitink/dS2

https://www.geosci-model-dev-discuss.net/gmd-2019-150/

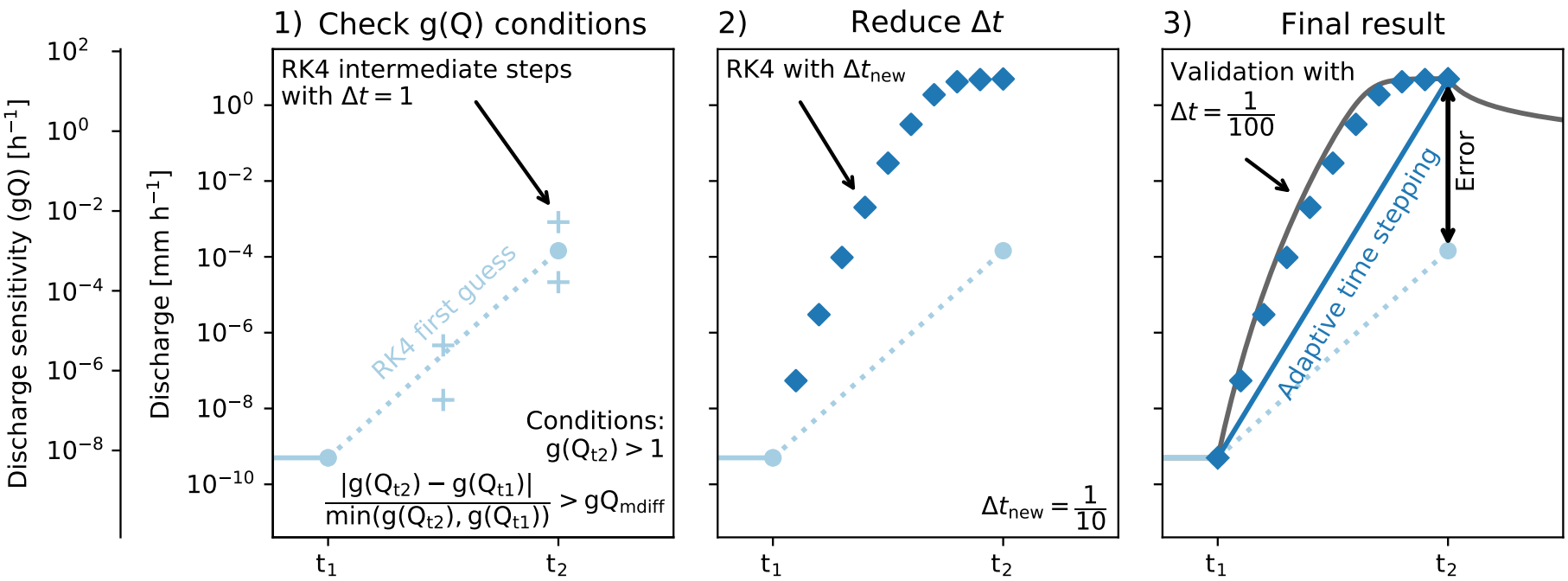
Numerical stability



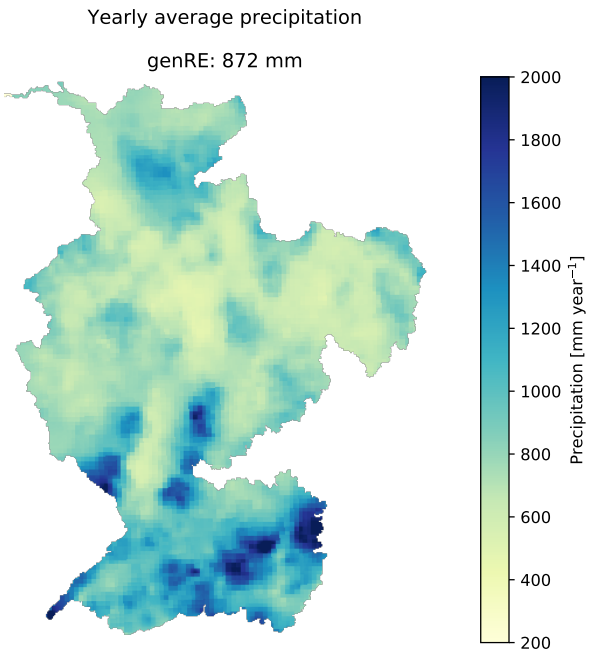
Numerical stability

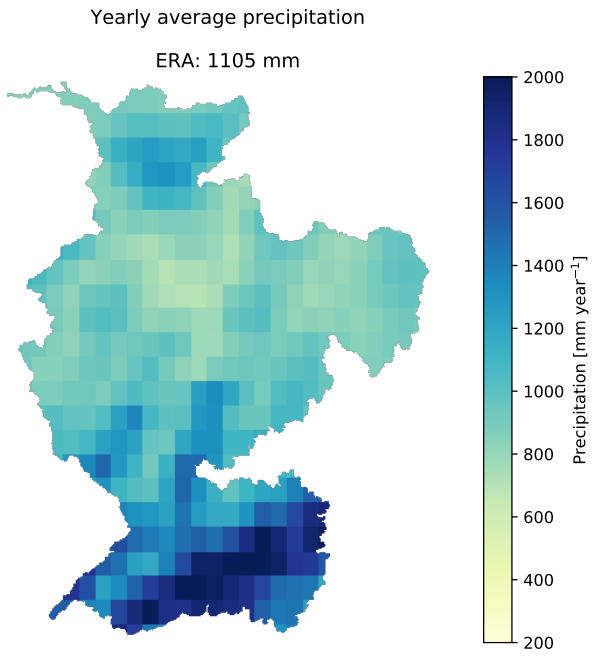


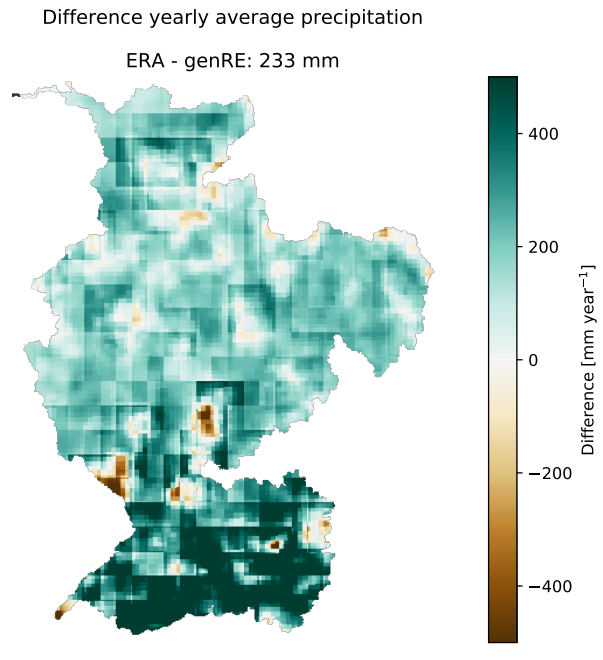
Numerical stability



Research plans – Precipitation products







Research plans – Evaporation-vegetation feedback