

An aerial photograph of a river valley. On the left, a wide river flows through a green valley. In the center, a road with a railway track runs parallel to the river. On the right, a large, historic church with a tall spire and Gothic-style windows is prominent. The background shows rolling green hills under a clear blue sky.

# The distributed simple dynamical systems model (dS2)

Computationally efficient hydrological modelling

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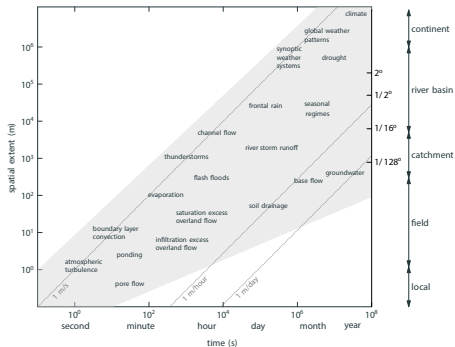
**WAGENINGEN**  
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# Motivation

Increasing computational power

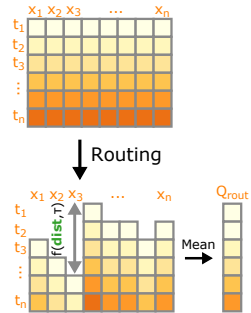
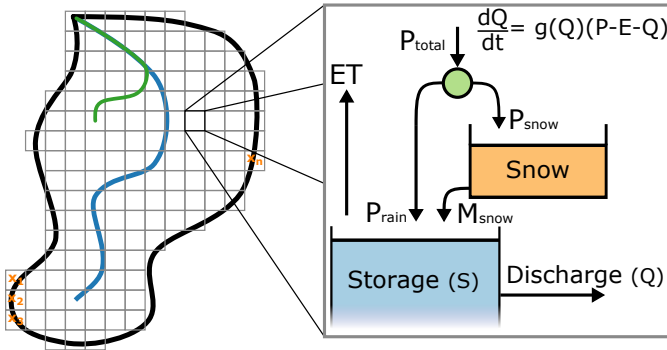
- Higher spatial resolutions vs temporal resolution
- Computational efficiency?

“Bucket”-based models

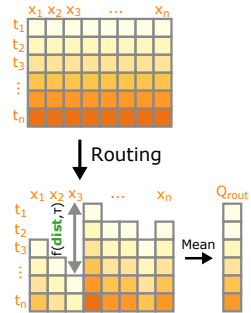
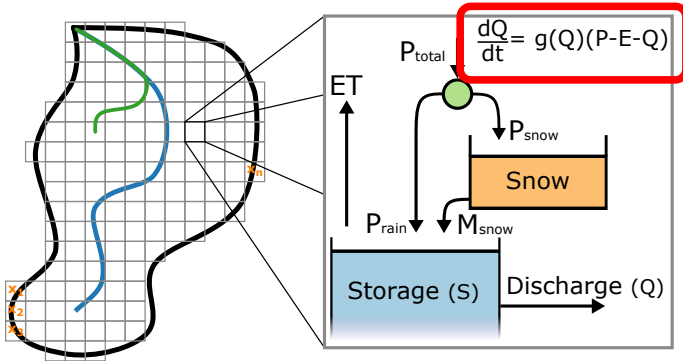


Melsen, L. A., Teuling, A. J., Torfs, P. J. J. F., Uijlenhoet, R., Mizukami, N., and Clark, M. P.: HESS Opinions: The need for process-based evaluation of large-domain hyper-resolution models, *Hydrol. Earth Syst. Sci.*, 20, 1069-1079, <https://doi.org/10.5194/hess-20-1069-2016>, 2016.

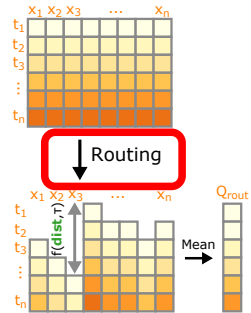
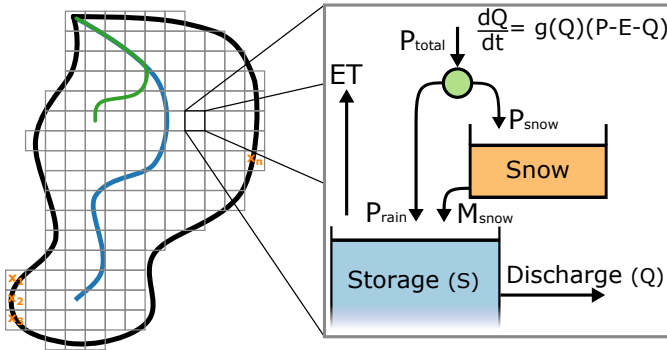
# dS2 in a single picture



# dS2 in a single picture



# dS2 in a single picture



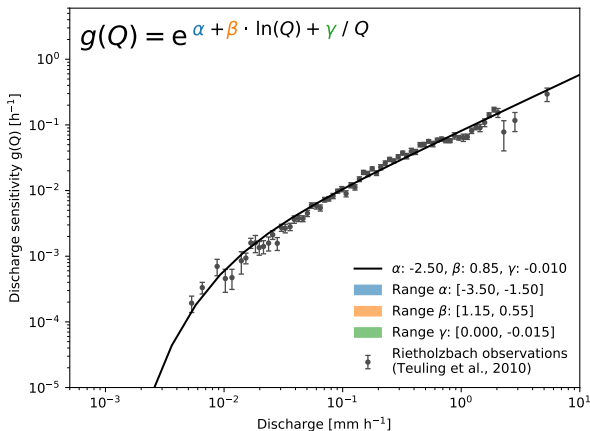
# Discharge sensitivity

$$\frac{dS}{dt} = P - E - Q$$

$$Q = f(S)$$

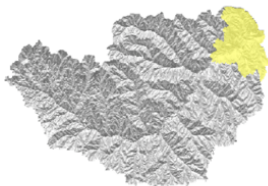
$$\begin{aligned}\frac{dQ}{dt} &= \frac{dQ}{dS} \cdot \frac{dS}{dt} \\ &= \frac{dQ}{dS} (P - E - Q)\end{aligned}$$

$$\frac{dQ}{dt} = g(Q)(P - E - Q)$$

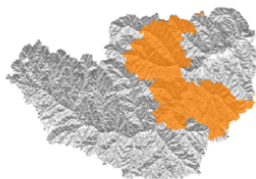


# Routing - width function

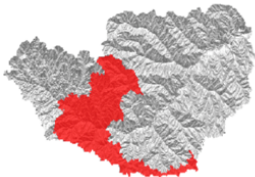
Sub-basin 1:  $d < 10$  Km



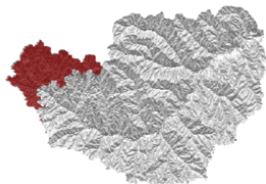
Sub-basin 2:  $15 < d < 25$  Km



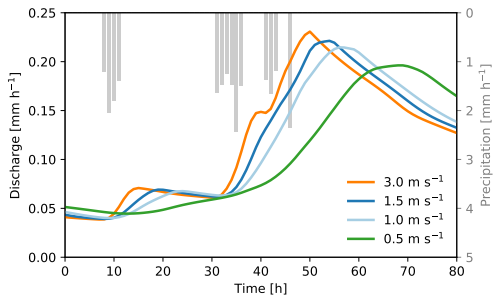
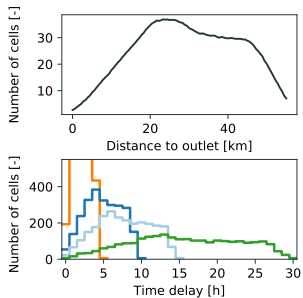
Sub-basin 3:  $35 < d < 45$  Km



Sub-basin 3:  $60 < d < 60$  Km



# Routing - width function

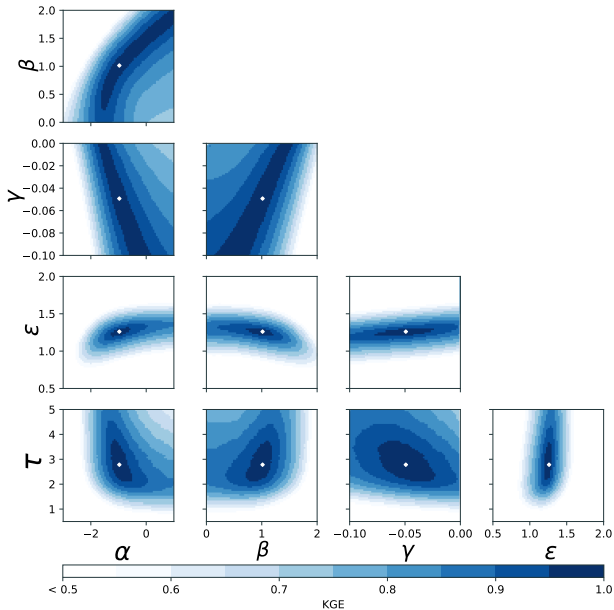




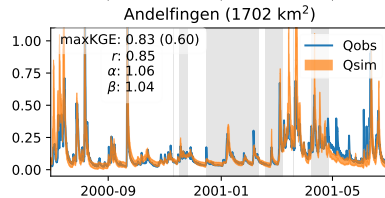
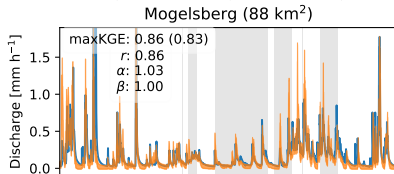
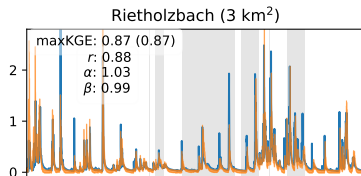
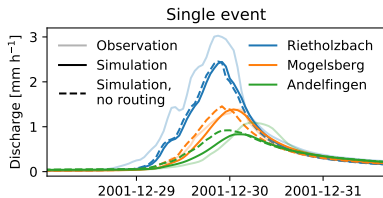
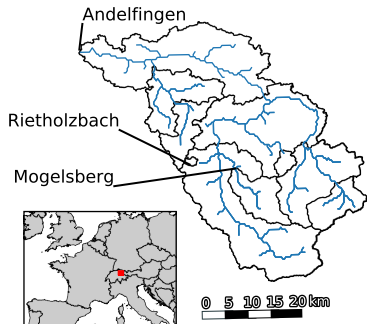
All runtimes are with **hourly** timestep

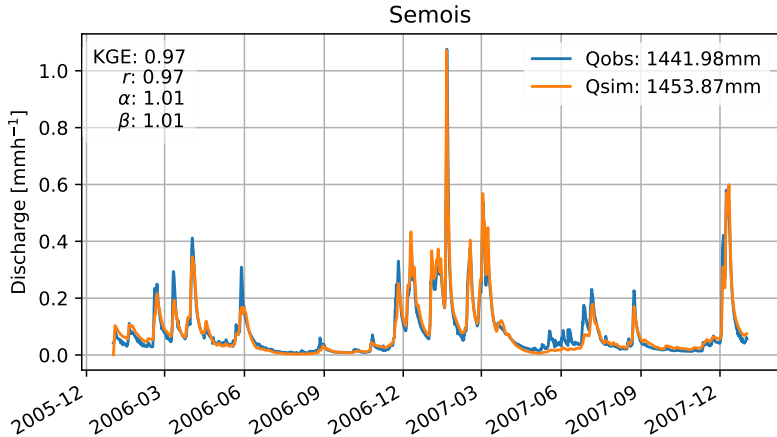
|  | Area | Resolution             | Period   | Runtime    |
|--|------|------------------------|----------|------------|
| Thur (1 700 km <sup>2</sup> )                  |      | 1 × 1 km <sup>2</sup>  | 1 year   | 3 seconds  |
| Rhine (185 000 km <sup>2</sup> )               |      | ±4 × 5 km <sup>2</sup> | 1 year   | 10 seconds |
| Europe (10 · 10 <sup>6</sup> km <sup>2</sup> ) |      | 5 × 5 km <sup>2</sup>  | 3 months | 6 minutes  |

# Parameter sensitivity

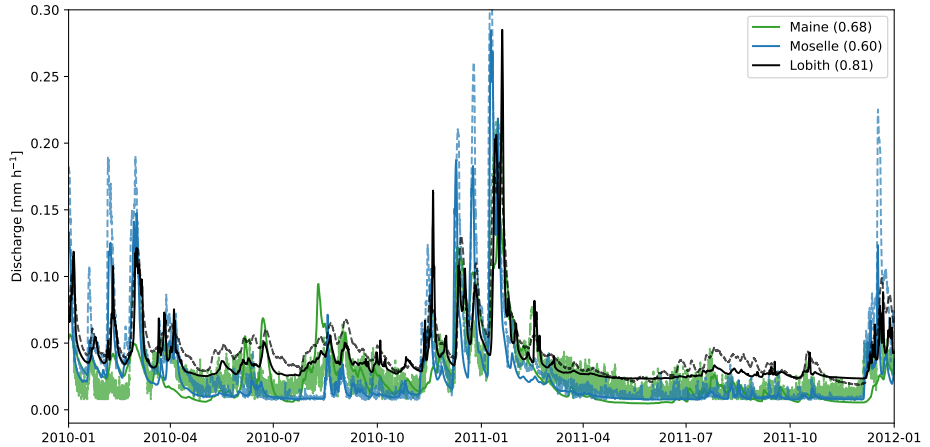


# Results Thur





# Results Rhine



# Questions?

JoostBuitink / dS2

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The distributed simple dynamical systems (dS2) model

Manage topics

7 commits 1 branch 1 release 1 contributor GPL-1.0

Branch master New pull request Create new file Upload files Pin file Clone or download

| File                    | Latest commit                                 | Created      |
|-------------------------|---|--------------|
| other                   | Calculate storage                             | 23 days ago  |
| other                   | Add files via upload                          | 2 months ago |
| g4lgrove                | Update g4lgrove                               | 2 months ago |
| UXNSI                   | Add files via upload                          | 2 months ago |
| RACM4.mxd               | Add files via upload                          | 2 months ago |
| dS2_model.py            | Bugfix for routing with different pixel sizes | 28 days ago  |
| dS2_settings_and_run.py | Add files via upload                          | 2 months ago |
| funcFlow.py             | Add files via upload                          | 2 months ago |
| funcParams.py           | Add files via upload                          | 2 months ago |
| funcRouting.py          | Bugfix for routing with different pixel sizes | 28 days ago  |
| funcSolve.py            | Calculate storage                             | 23 days ago  |
| readOutput.py           | Add files via upload                          | 2 months ago |
| readOutput.py           | Add files via upload                          | 2 months ago |

## Model description paper

14 Jun 2019

### A distributed simple dynamical systems approach (dS2 v1.0) for computationally efficient hydrological modelling

Joost Buitink<sup>1</sup>, Lieke A. Melsen<sup>1</sup>, James W. Kirchner<sup>2,3,4</sup>, and Adriaan J. Teuling<sup>1</sup>

<sup>1</sup>Hydrology and Quantitative Water Management Group, Wageningen University, Wageningen, The Netherlands

<sup>2</sup>Department of Environmental Systems Science, ETH Zurich, Zurich, 8092, Switzerland

<sup>3</sup>Swiss Federal Research Institute WSL, Birmensdorf, 8903, Switzerland

<sup>4</sup>Department of Earth and Planetary Science, University of California, Berkeley, California, 94720, USA

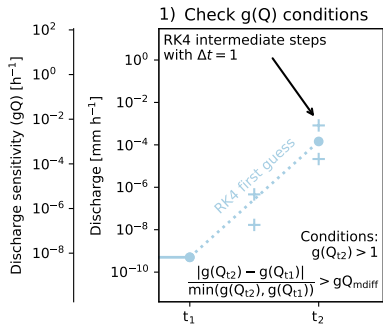
#### Review status

This discussion paper is a preprint. It is a manuscript under review for the Journal Geoscientific Model Development (GMD).

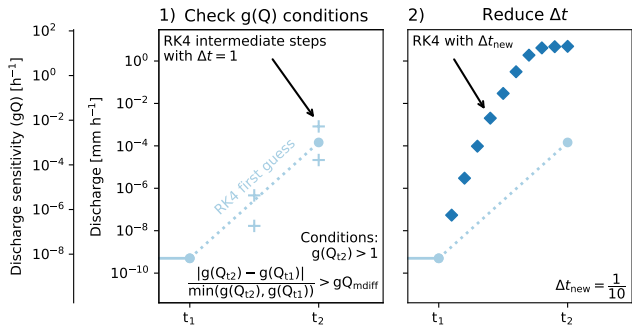
<https://github.com/JoostBuitink/dS2>

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

# Numerical stability

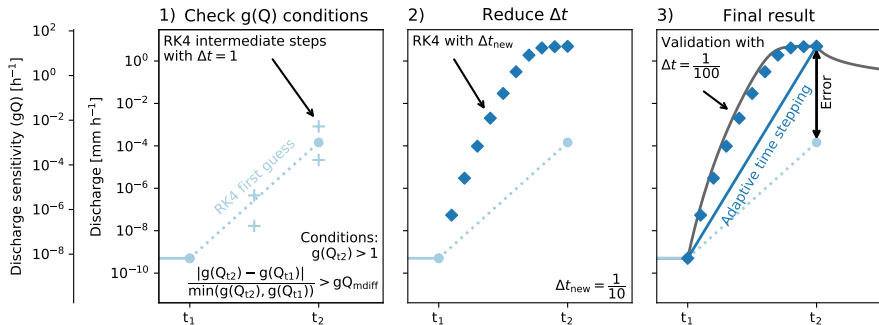


# Numerical stability





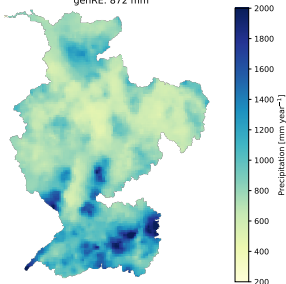
# Numerical stability



# Research plans – Precipitation products

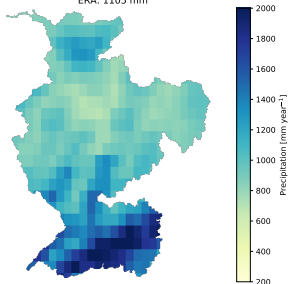
Yearly average precipitation

genRE: 872 mm



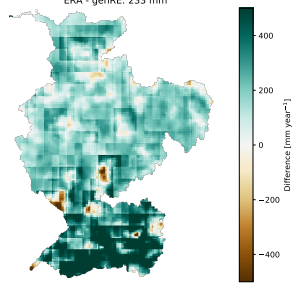
Yearly average precipitation

ERA: 1105 mm



Difference yearly average precipitation

ERA - genRE: 233 mm



# Research plans – Evaporation-vegetation feedback

