HELMHOLTZ Centre for Environmental Research

HOME

PICO screen 4.6

This presentation participates in OSPP

Outstanding Student Poster & PICO Contest

EGU23-7545

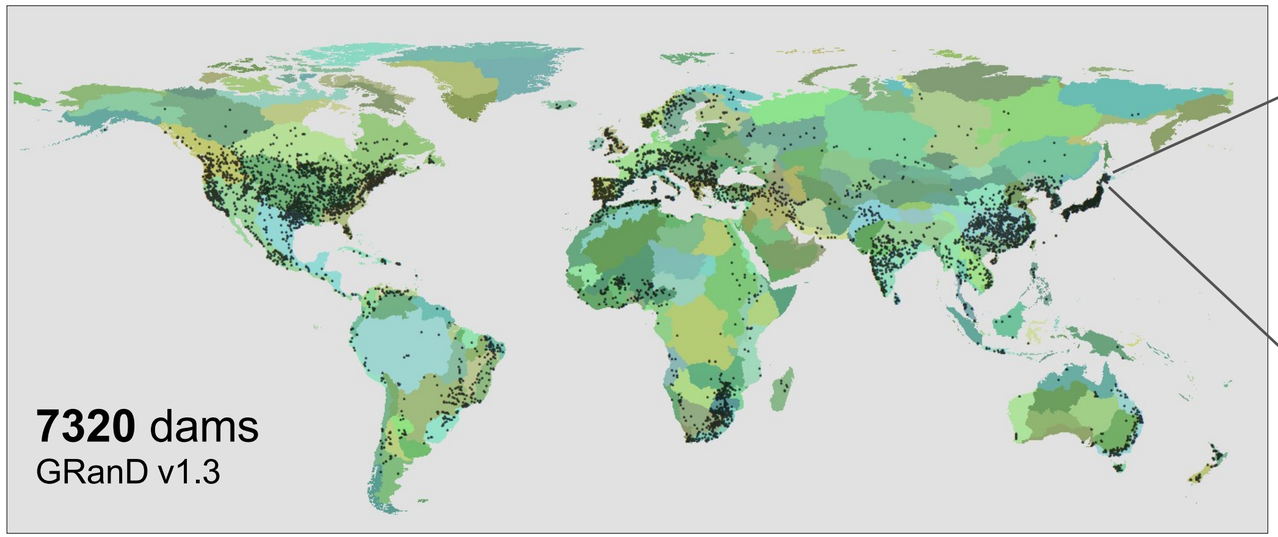
The Quest for Scalable Hydrological System for Reservoir Modeling

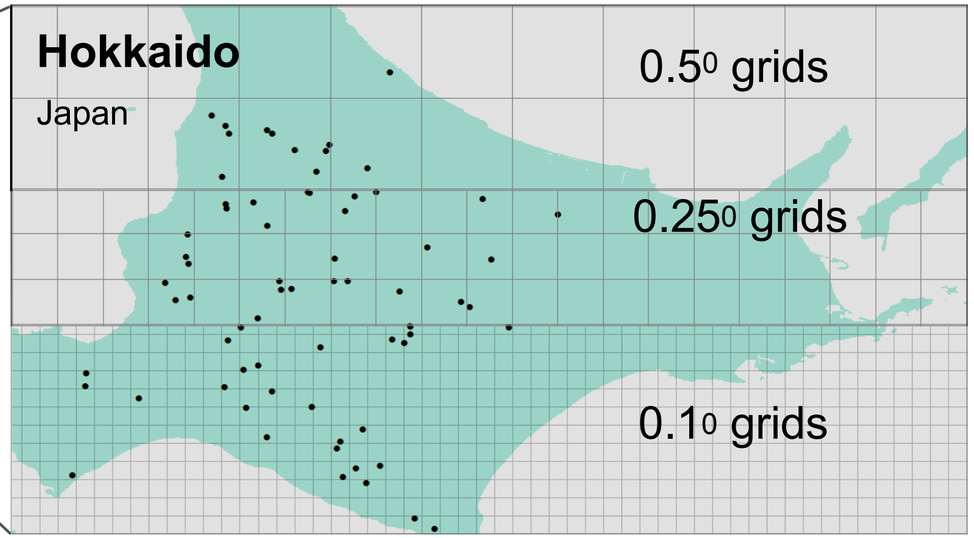
Pallav Kumar Shrestha, Luis Samaniego, Oldrich Rakovec, Stephan Thober

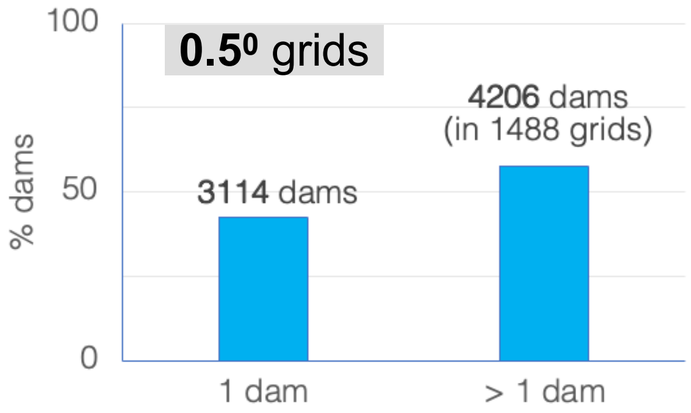
26.04.2023

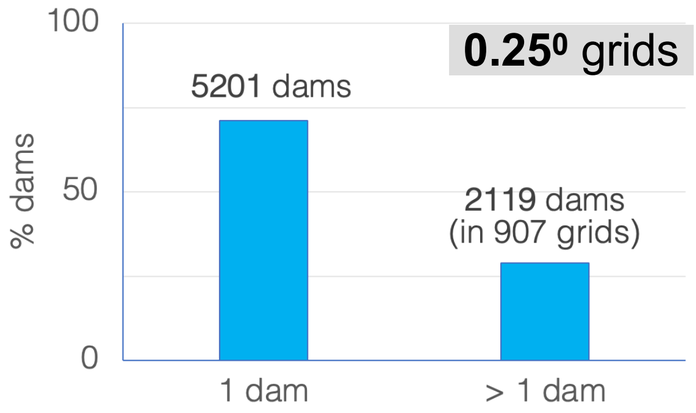
MOTIVATION

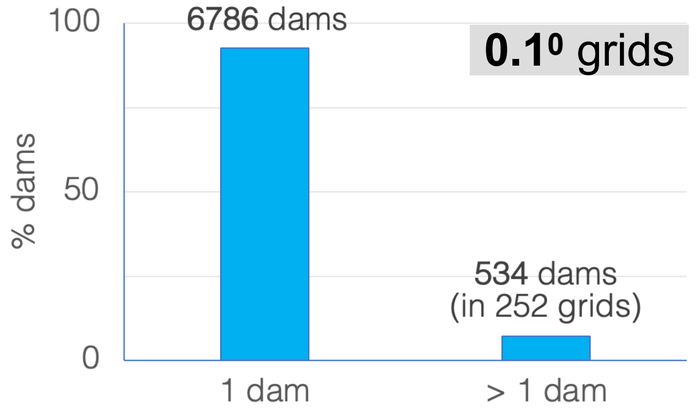
Reservoirs vs Scales (**Global**, **Continental**, **Regional**)





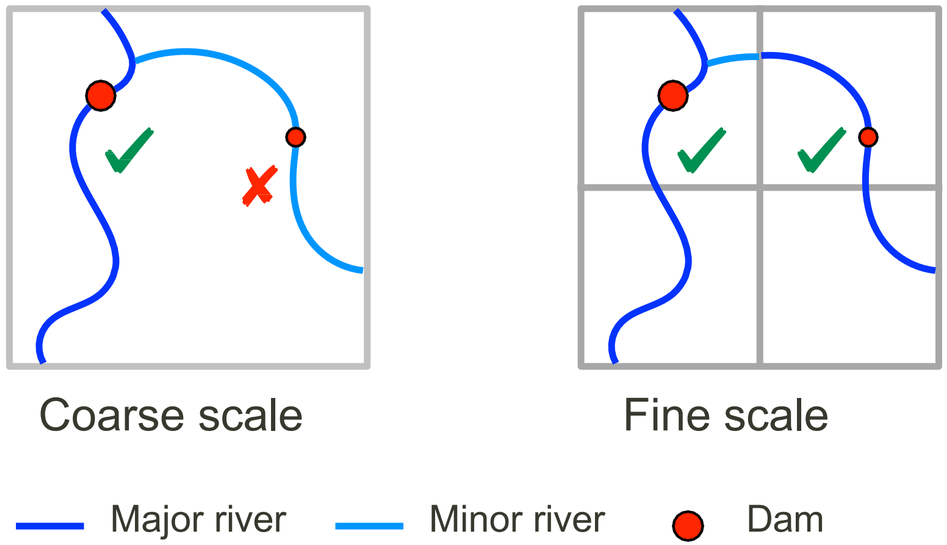






STATE-OF-THE-ART
Inconsistencies across scales

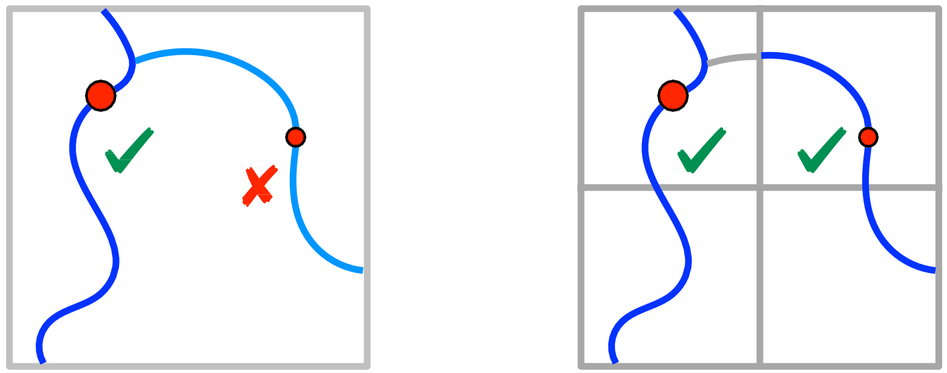
Approach 1 — Select big, drop small



Haddeland et al. (2006), Zhao et al. (2016), Zajac et al. (2017), Sutanudjaja et al. (2018), Shin et al. (2019), Shin et al. (2020), Dang et al. (2020),

STATE-OF-THE-ART
Inconsistencies across scales

Approach 1 — Select big, drop small

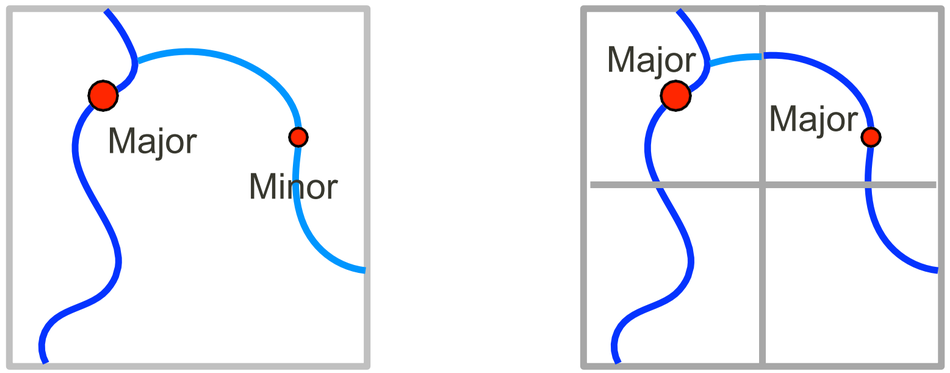


Coarse scale | Fine scale

Major river | Minor river | Dam

Haddeland et al. (2006), Zhao et al. (2016), Zajac et al. (2017), Sutanudjaja et al. (2018), Shin et al. (2019), Shin et al. (2020), Dang et al. (2020),

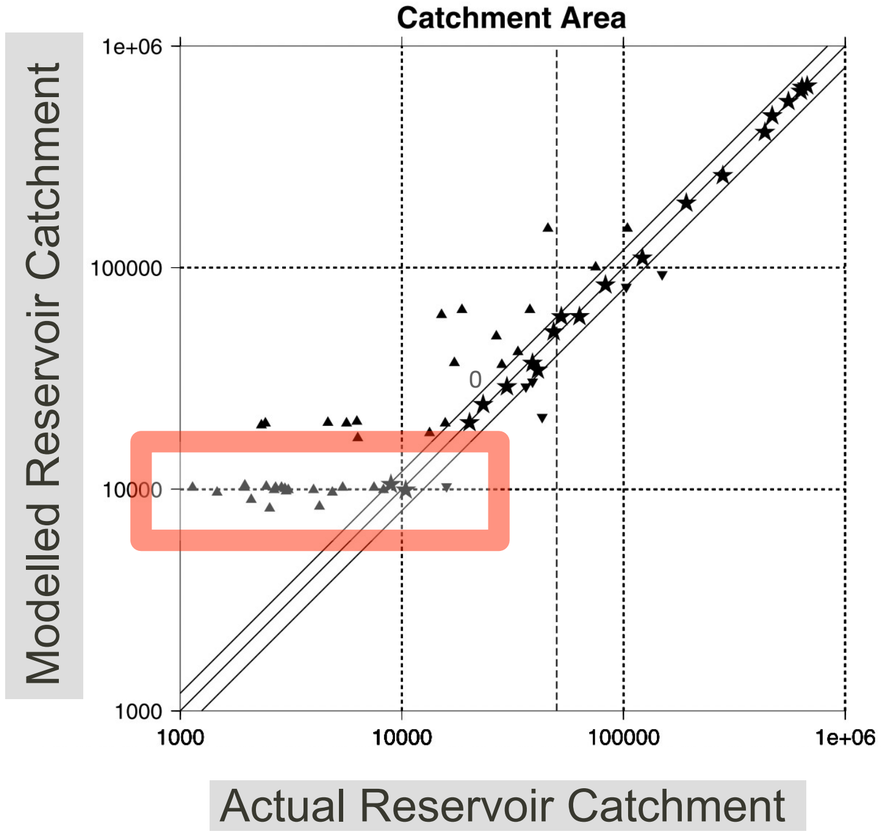
Approach 2 — Reservoir groups



Coarse scale | Fine scale

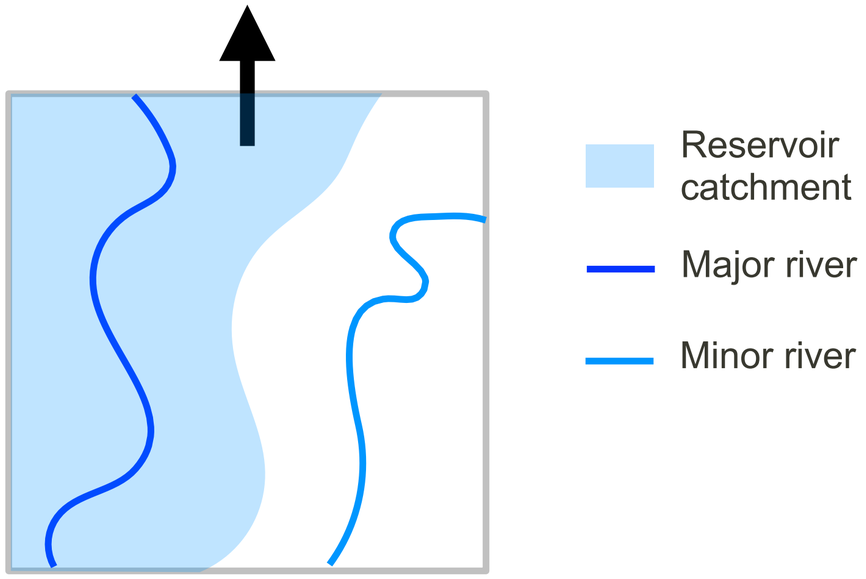
Hanasaki et al. (2006), Wisser et al. (2010), Burek et al. (2020), Müller Schmied et al. (2020)

HYPOTHESIS
A clue from Hanasaki (2006)



State-of-the-art distributed routing —

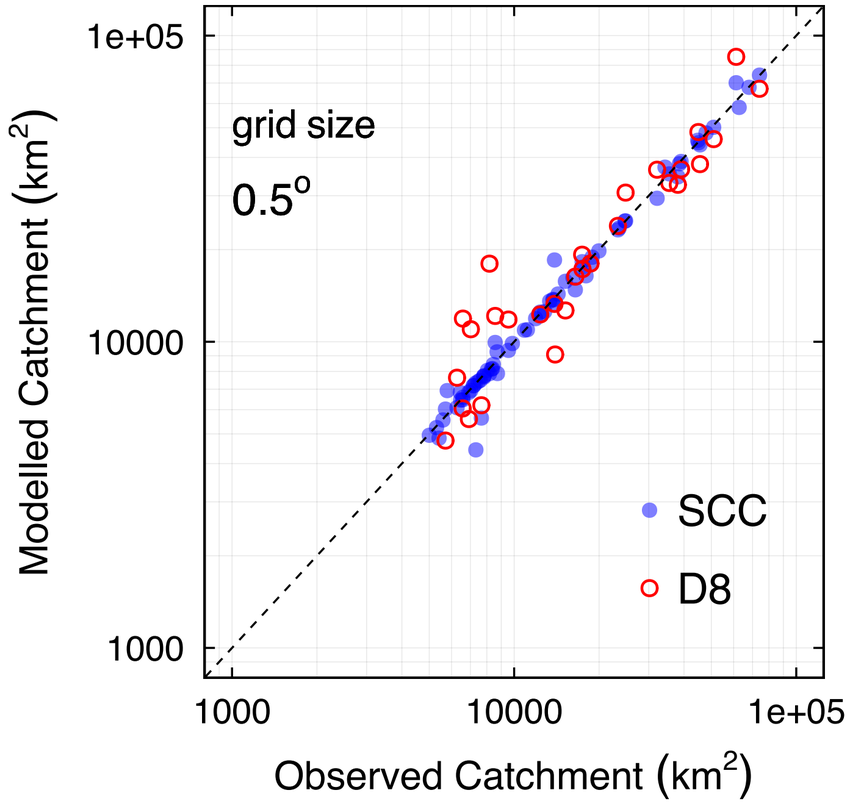
All the water of the grid follows the **major** river

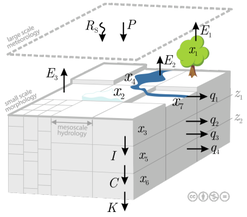


Source: Hanasaki et al. (2006) JoH

HYPOTHESIS

Subgrid Catchment Convervation (**SCC**)

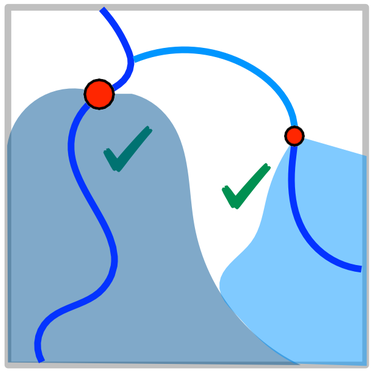




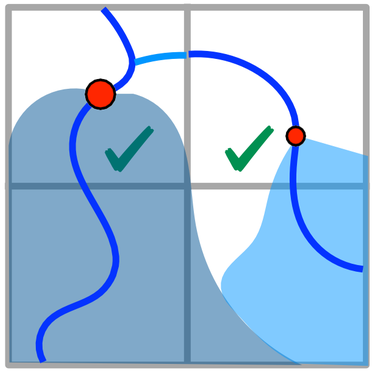
mHM

mesoscale Hydrological Model

https://mhm-ufz.org/



Coarse scale



Fine scale

Consistent catchment across scales

Consistent reservoir set across scales

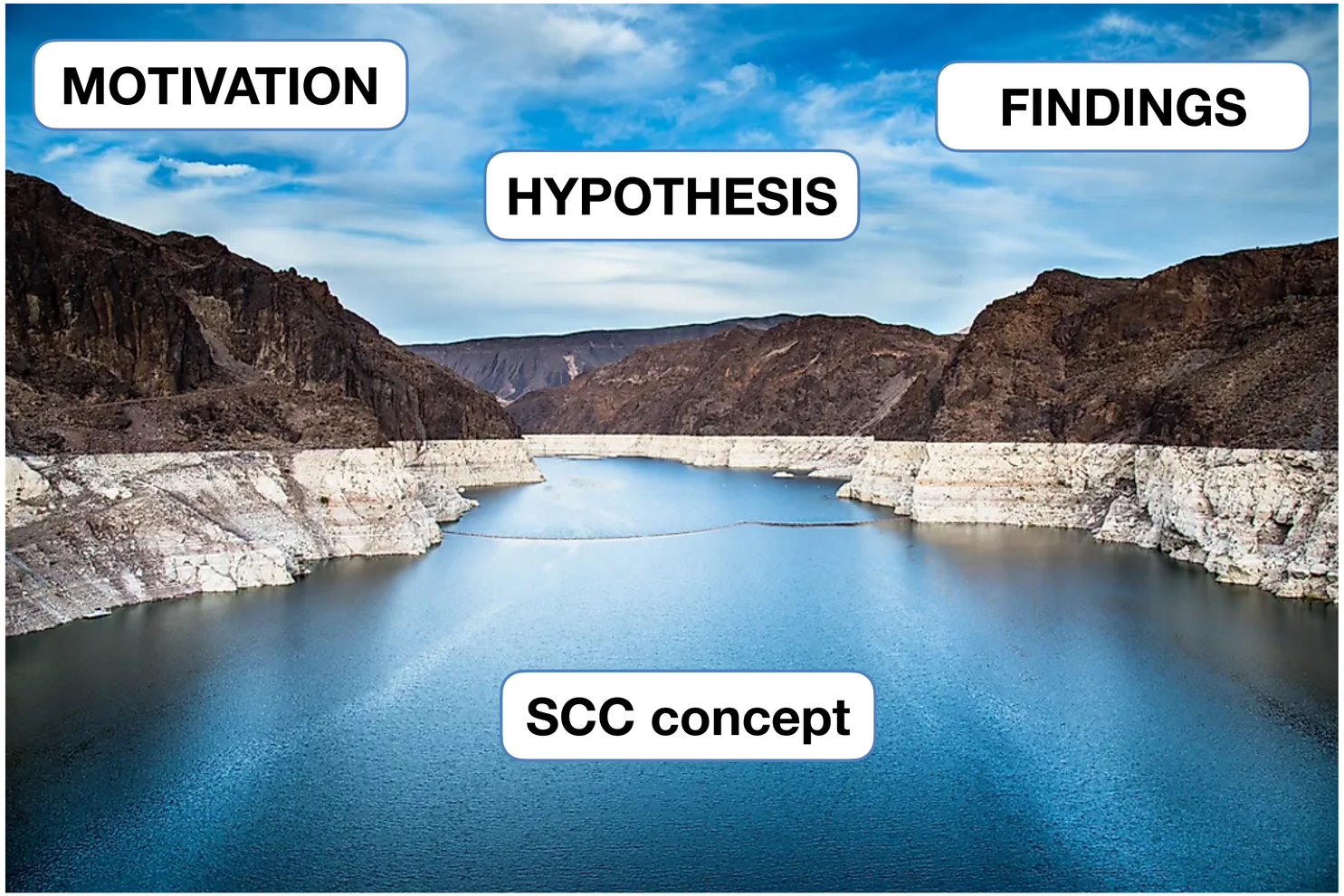
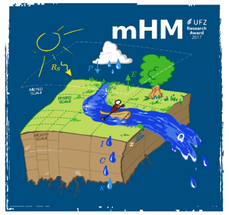


Image source: https://www.worldatlas.com/articles/the-largest-reservoirs-in-the-united-states.html

Want to know about

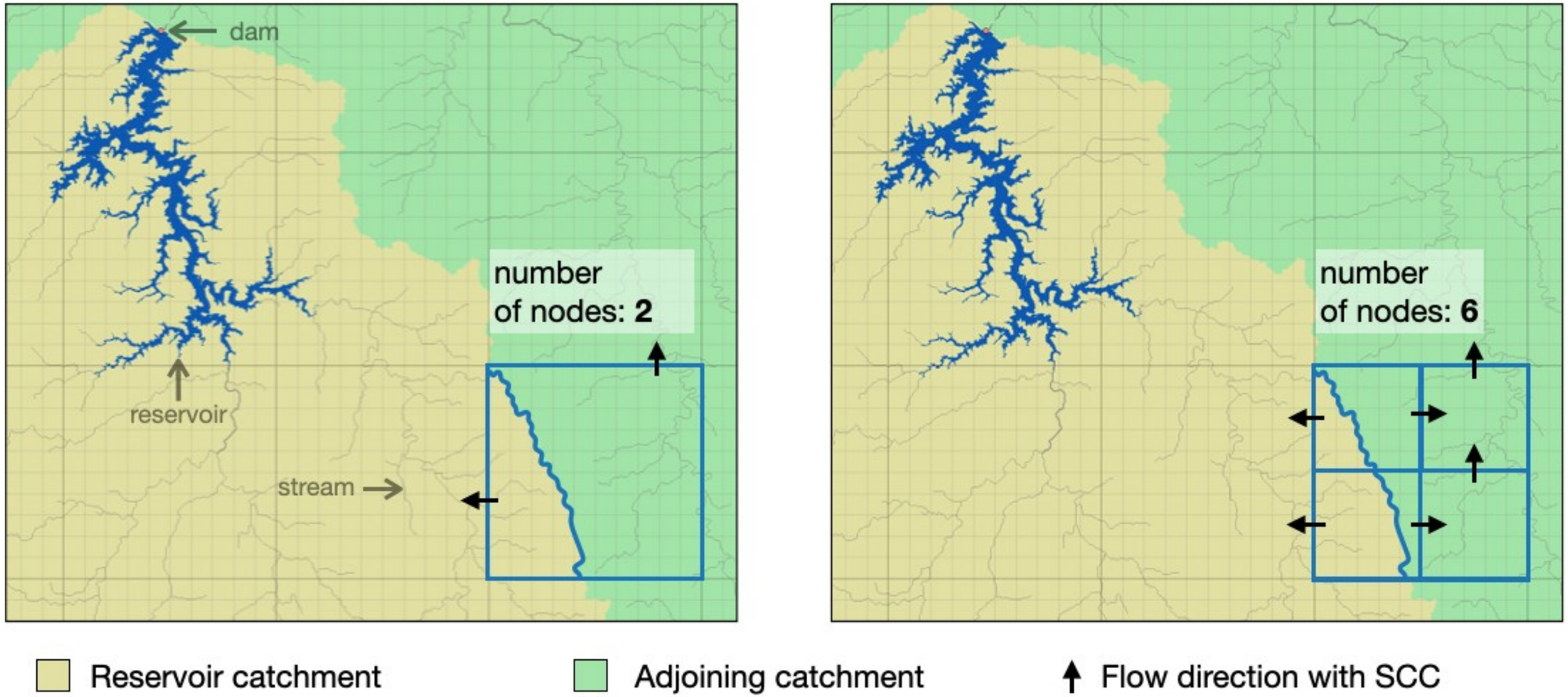


mHM? Click here!
mesoscale Hydrological Model

Want support on using mHM?

Joing Github mHM Discussion at
https://github.com/mhm-ufz/mhm/discussions

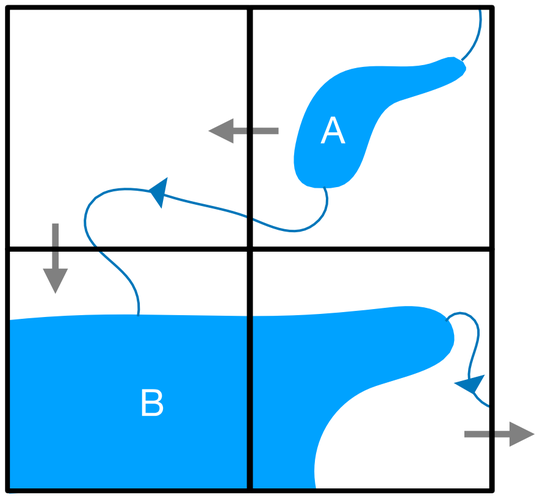
SCC
Subgrid Catchment Contribution



SCC
Subgrid Catchment Contribution

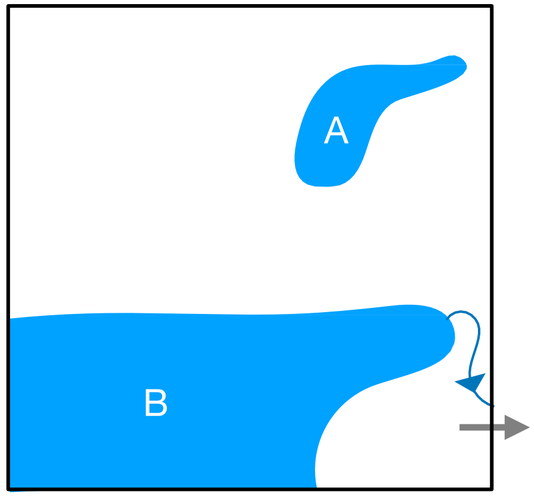
D8

4 nodes



Fine resolution

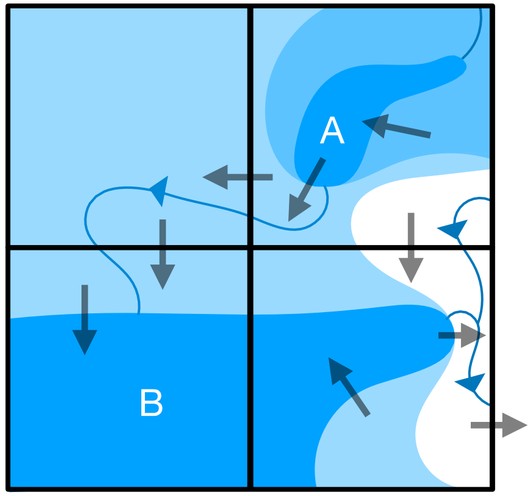
1 node



Coarse resolution

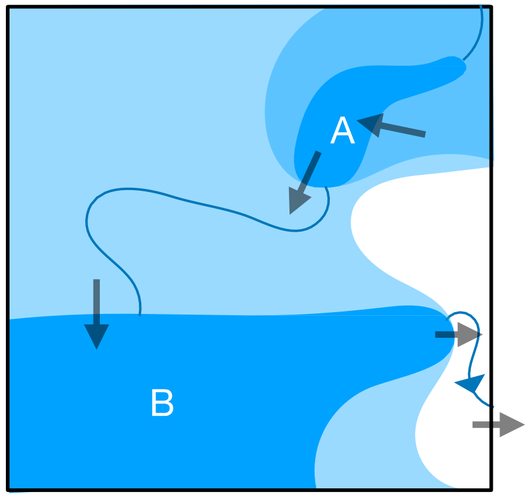
SCC

7 nodes



Fine resolution

3 nodes



Coarse resolution

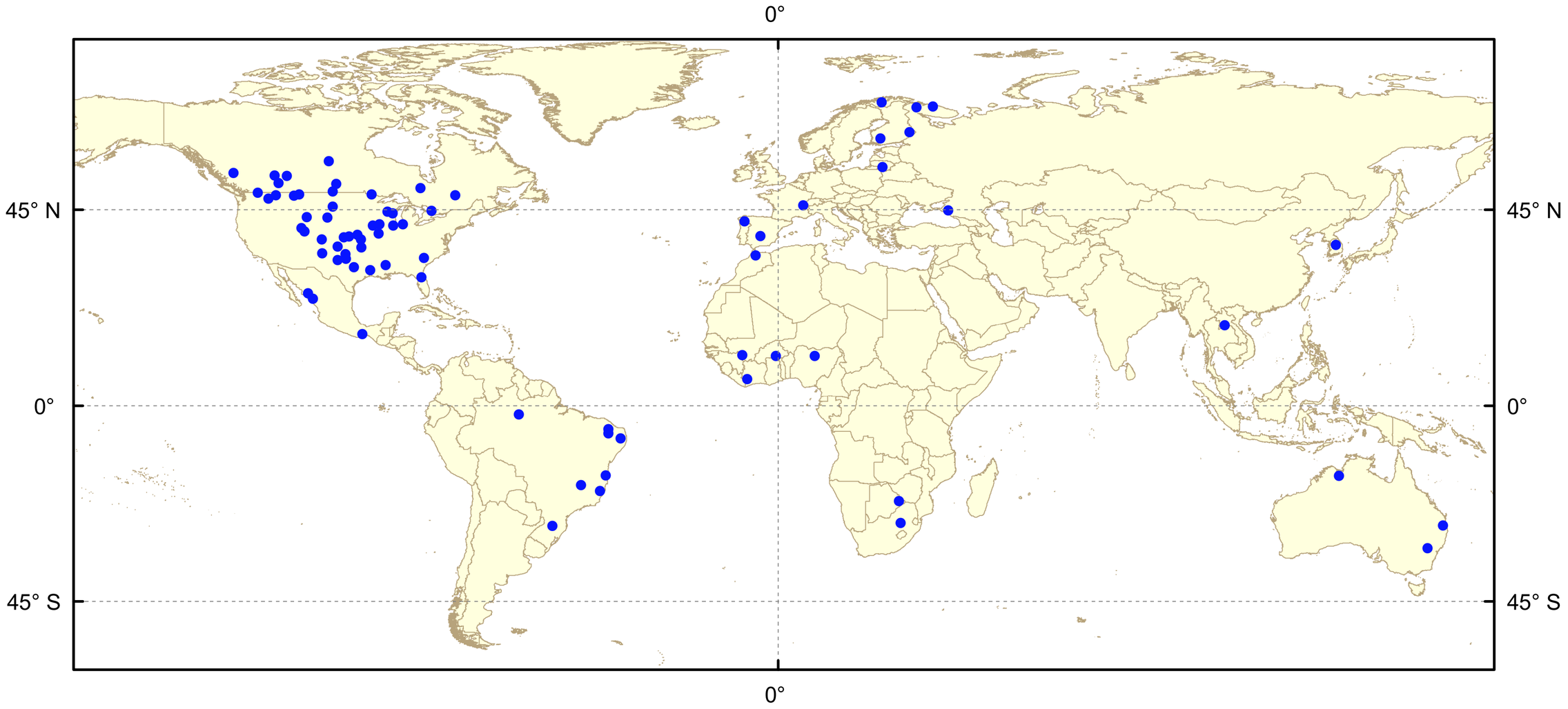
O'Callaghan & Mark (1984): Extraction of Drainage Networks

EGU2023-7545

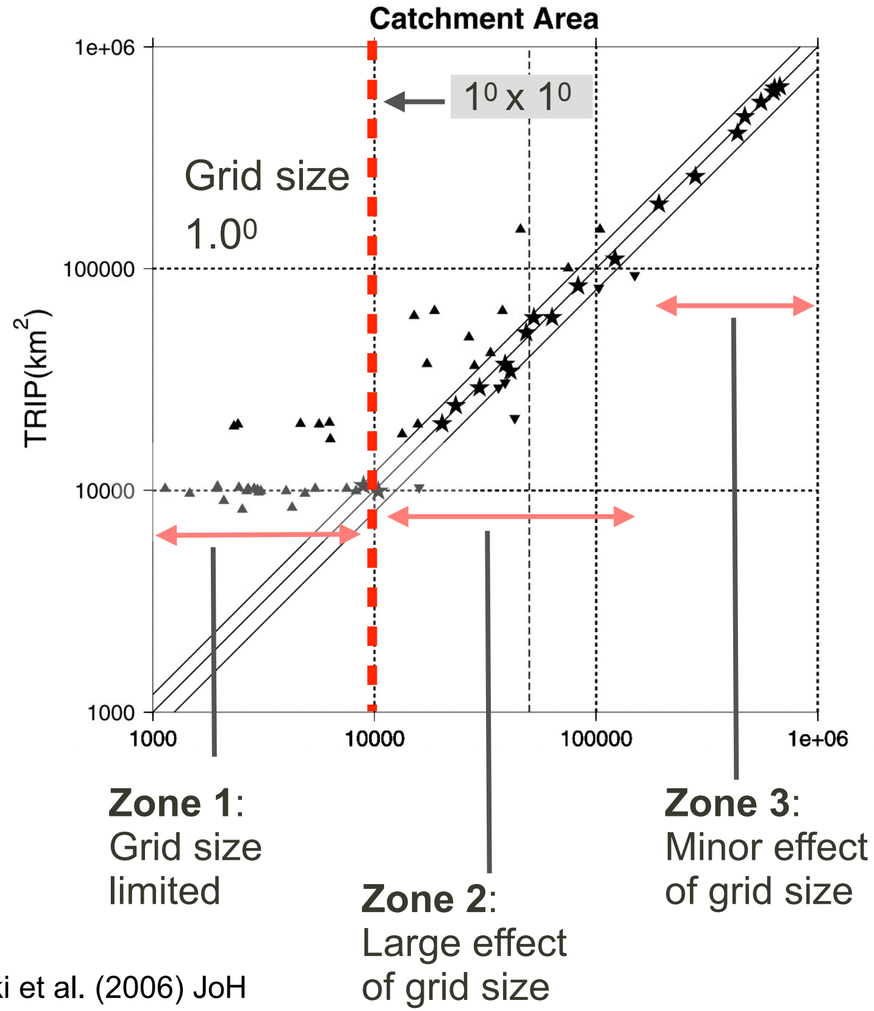
PICO screen 4.6

FINDINGS I

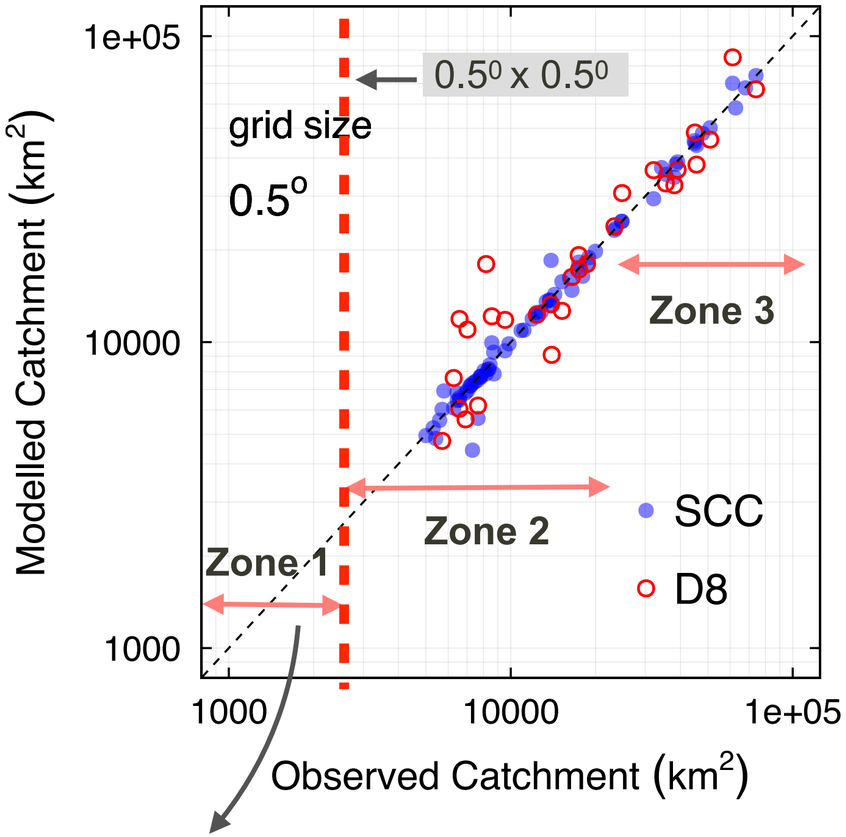
Pilot Experiment — 70+ global reservoirs



FINDINGS I
Consistency of Catchment across Scales



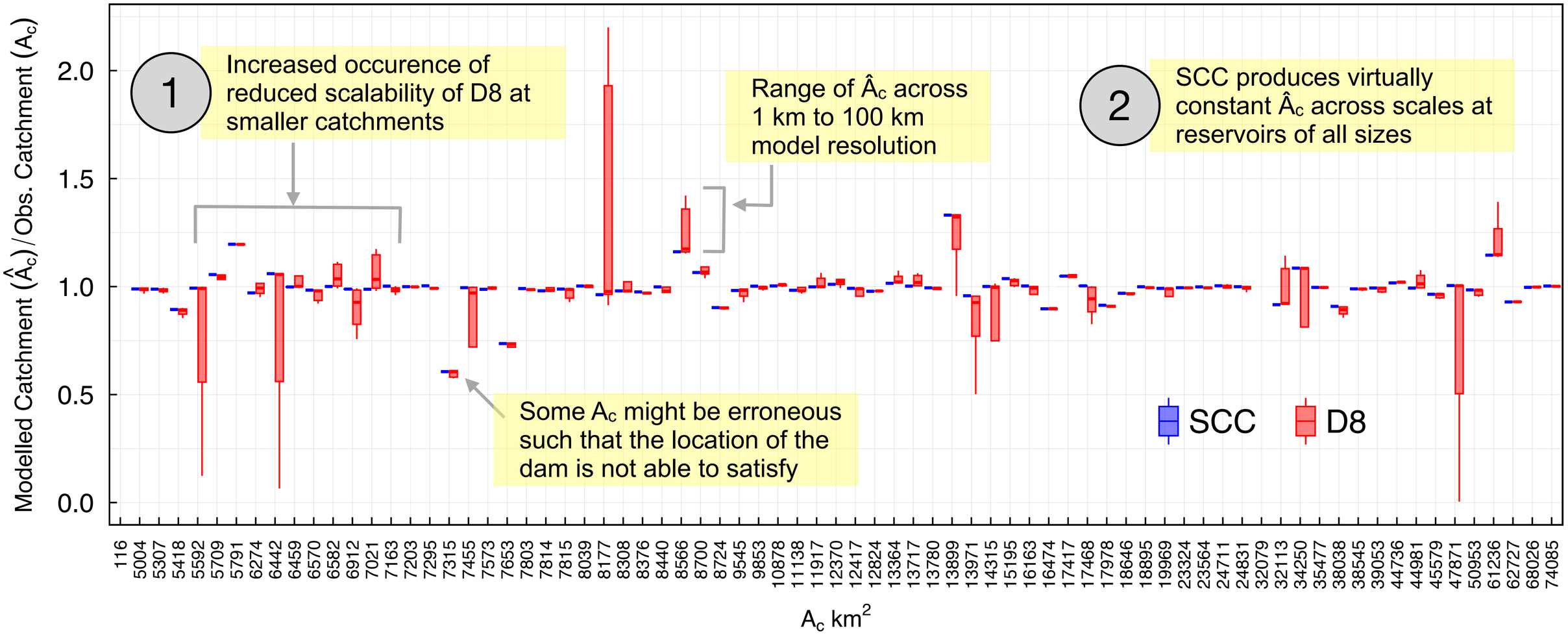
Source: Hanasaki et al. (2006) JoH



Revisit experiment and include smaller reservoirs

FINDINGS I

Consistency of Catchment across Scales



FINDINGS II

Inflow Forecasts — Experiment

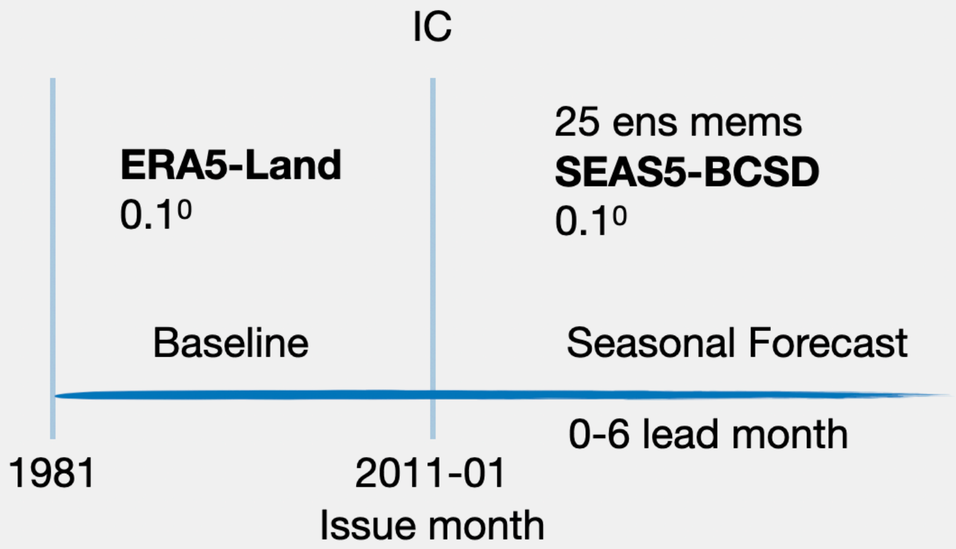
2. Poco da Cruz (c.a. 4,850 km²)

4. Sobradinho (c.a. 500,632 km²)
represents 60.4% of the hydroelectric power resources of the Northeast Brazil

3. Trés Marias (c.a. 50,816 km²)
South America's first major hydroelectric power plant

1. Serra Azul (c.a. 256 km²)
A tailing dam for structures downstream

6x model resolutions
mHM 0.05⁰, 0.10⁰, 0.15⁰, 0.20⁰, 0.25⁰, 0.50⁰



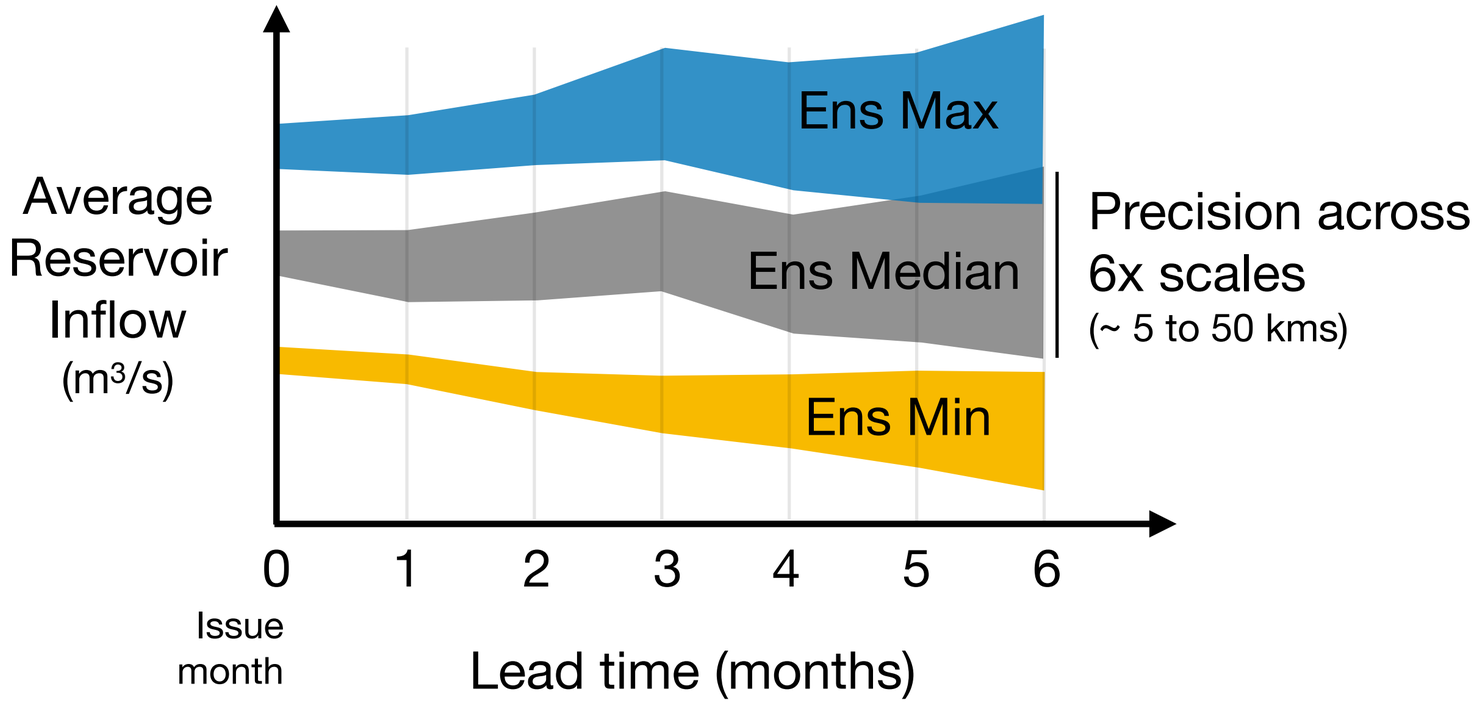
SEAS5-BCSD - We bias corrected and spatially downscaled seasonal forecasts from its native 35km resolution to 0.1⁰ using ERA5-Land

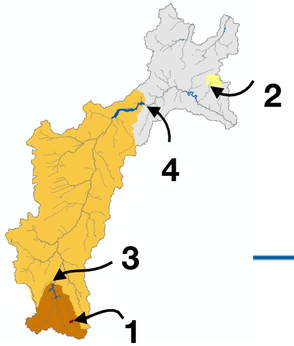
c.a. : catchment area. IC: initial condition

FINDINGS II

Inflow Forecasts — Graph Definition

GRAPH DEFINITION



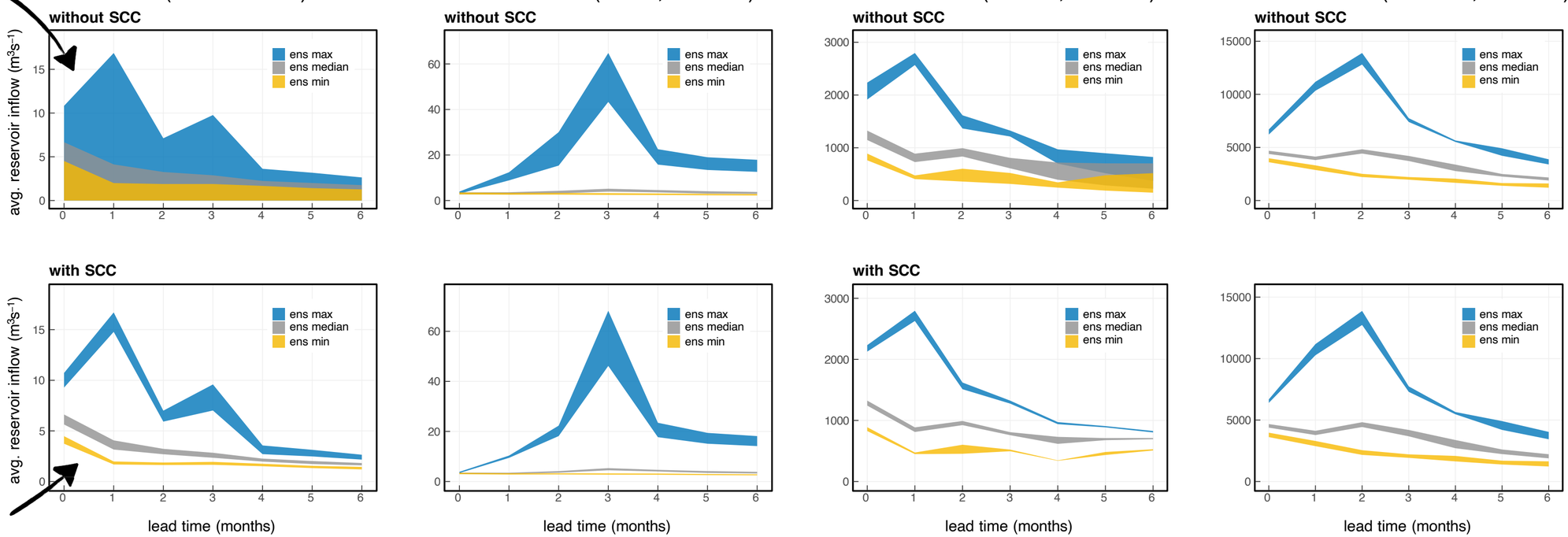


FINDINGS II
Inflow Forecasts

Forecast scalability is critical for smaller reservoirs! (relative to model grid)

1 **2** **3** **4**

Serra Azul (c.a. 256 km²) | Poco da Cruz (c.a. 4,850 km²) | Trés Marias (c.a. 50,816 km²) | Sobradinho (c.a. 500,632 km²)



! Model didn't resolve the small reservoir at 0.50⁰, 0.25⁰, 0.20⁰, 0.15⁰. All the lower limits of spread for ens max/min/median are zero!

Without SCC

reduced forecast uncertainty across modeling scales using SCC

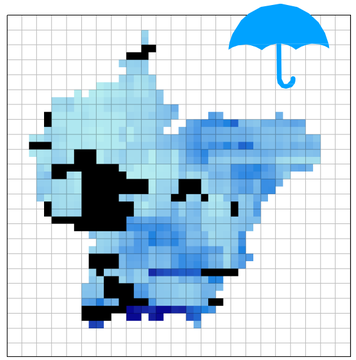
With SCC

✓ Model correctly resolved the small reservoir at all resolutions incl. 0.50⁰

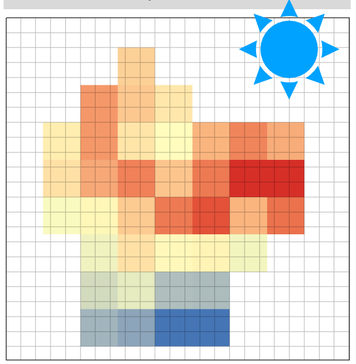
mHM 101

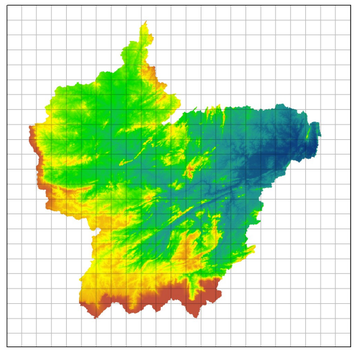
Resolutions of Morphology, Meteorology, Hydrology

CHIRPSv2 (0.05 deg)
Climate Hazard Group (CHG) UC Santa Barbara



PGFv3 (0.25 deg)
Princeton University



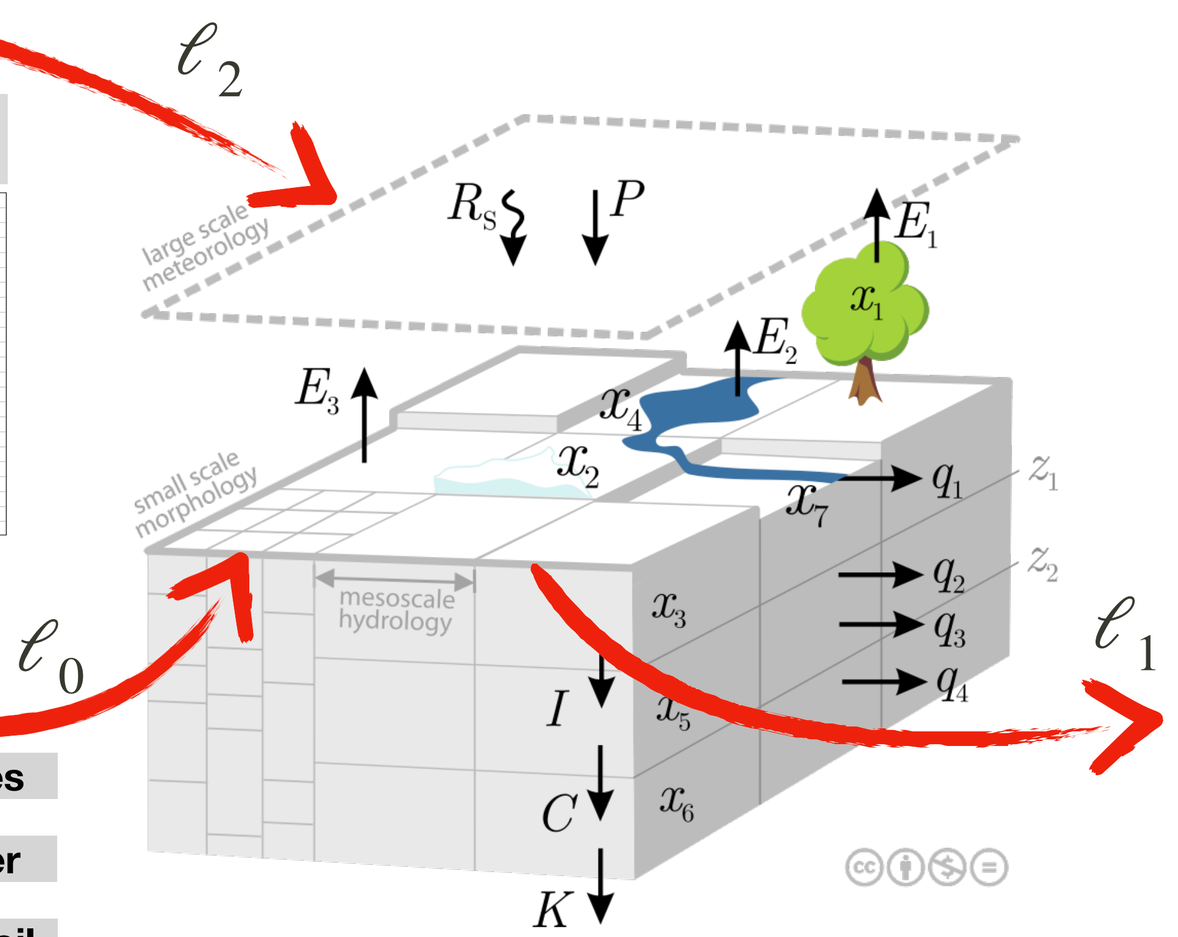


(0.002 deg)

DEM & derivatives

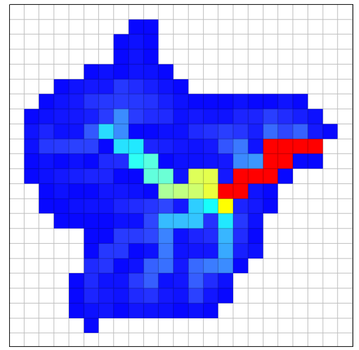
LAI **Land cover**

Geology **Soil**



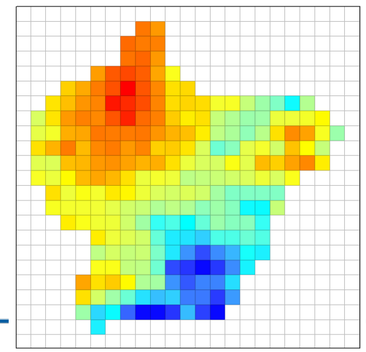
(0.1 deg)

Routed Streamflow



(0.1 deg)

Soil Moisture



Basin: Orós Reservoir Basin, Brazil

mHM 101
Scale Invariance

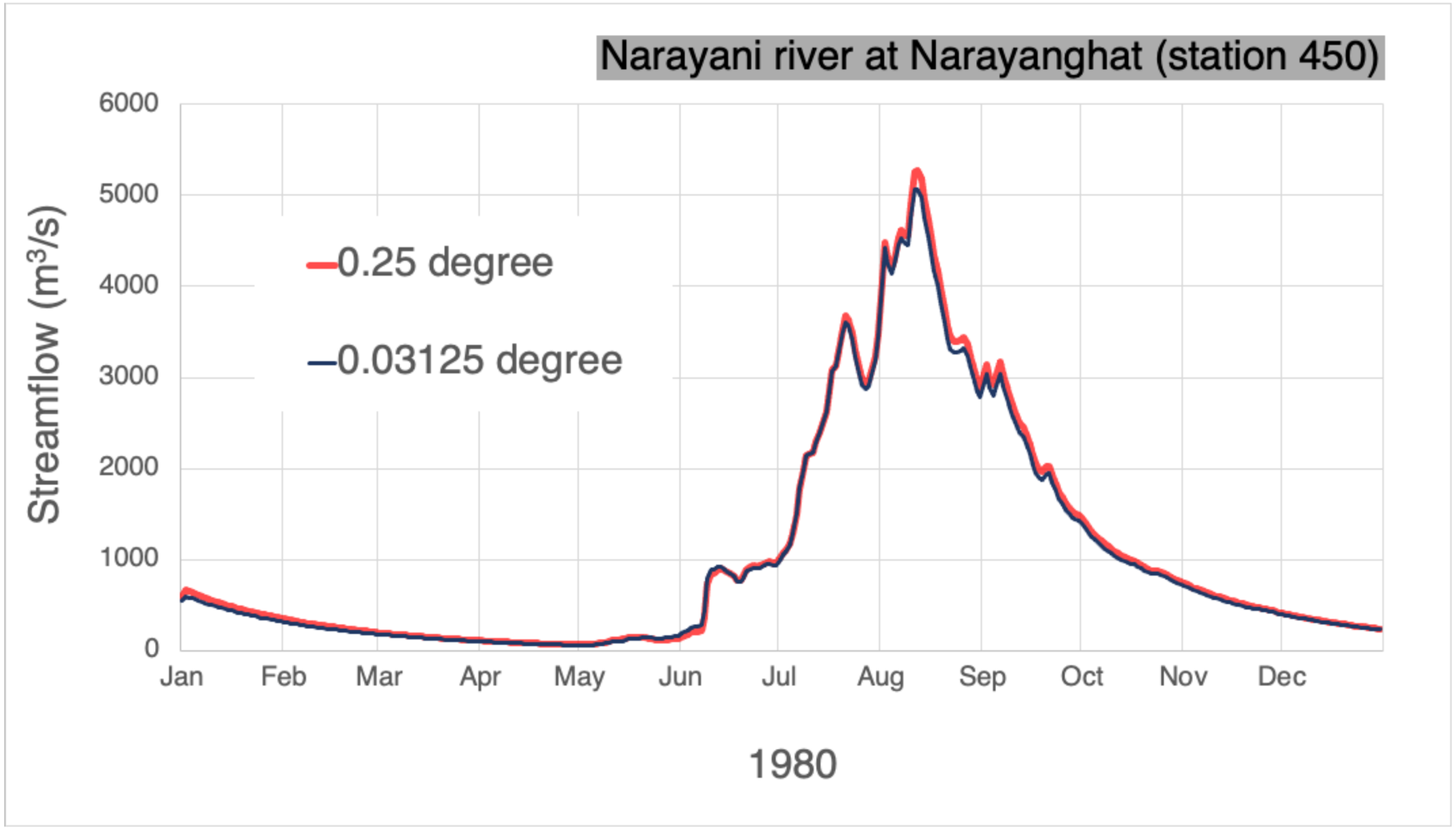
L1 = 0.25^0 (~**27 km**)

Calibration

Parameter transfer

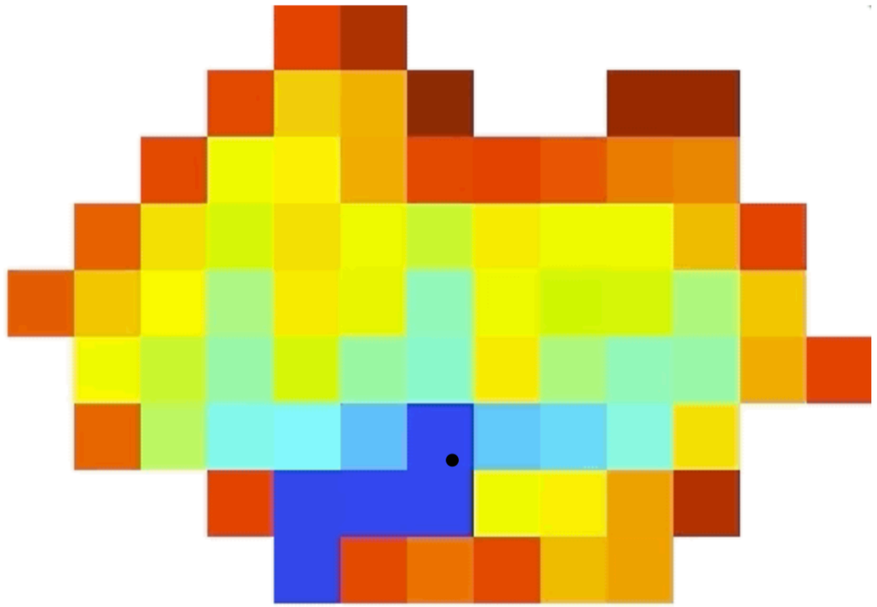
L1 = 0.03125^0 (~**4 km**)

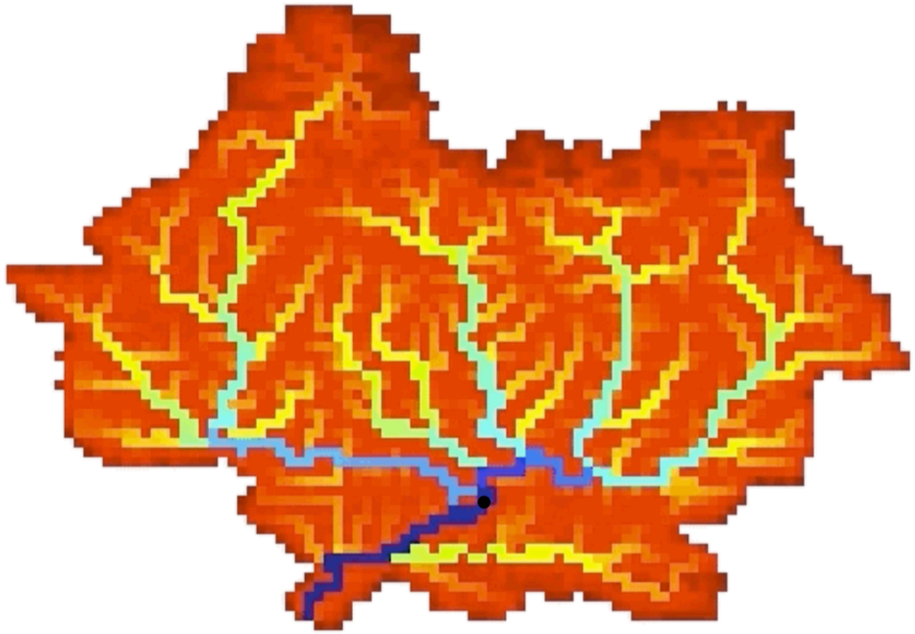
Analysis



mHM 101
Scale Invariance

Calibration L1 = 0.25° (~**27 km**) → Parameter transfer → L1 = 0.03125° (~**4 km**) Analysis



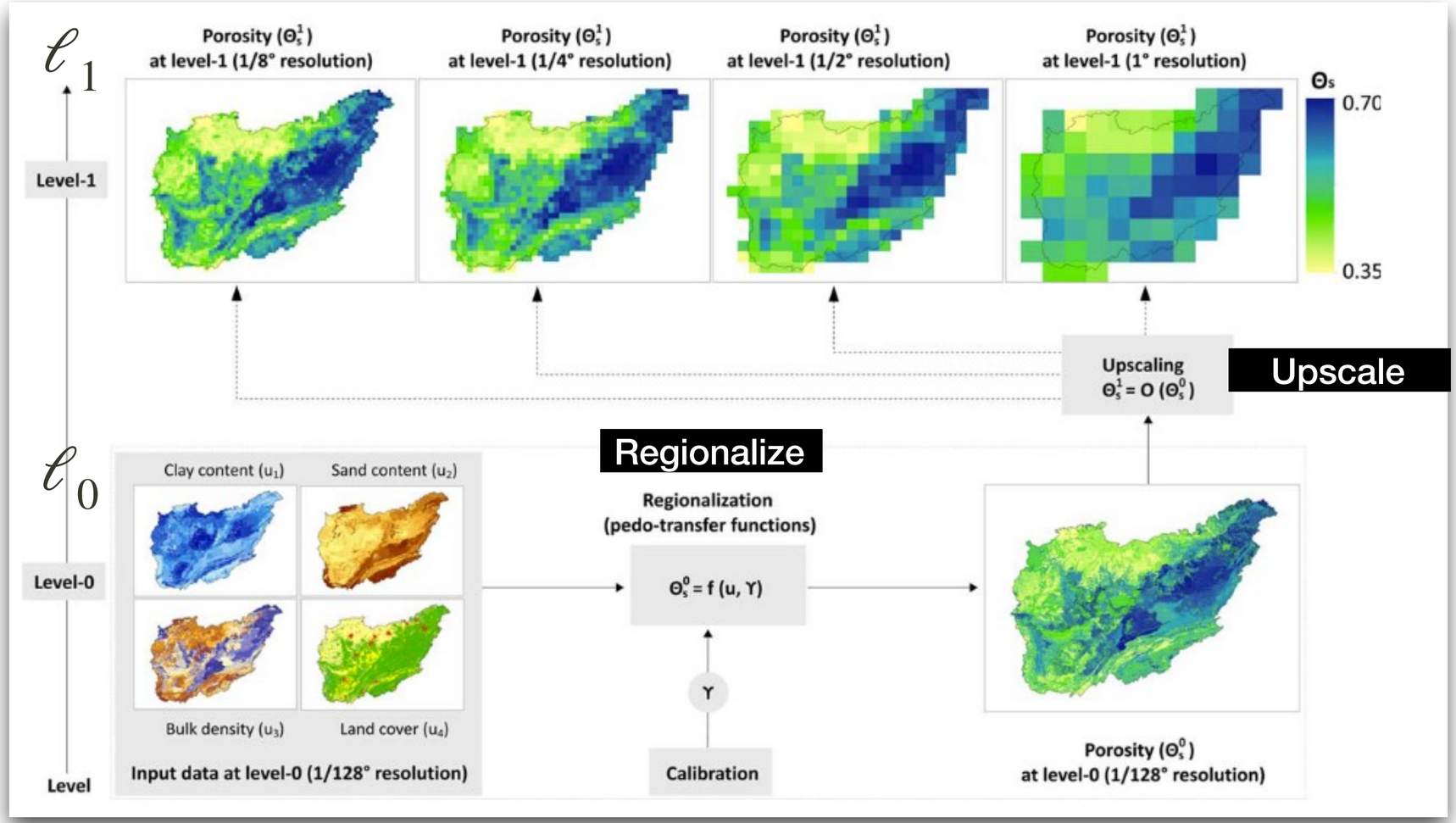


mHM 101
Multiscale Parameter Regionalisation

Multiscale Parameter Regionalization, **MPR**

First Regionalize the model parameter from predictor variables at Level-0

Then Upscale the parameter field from Level-0 to Level-1



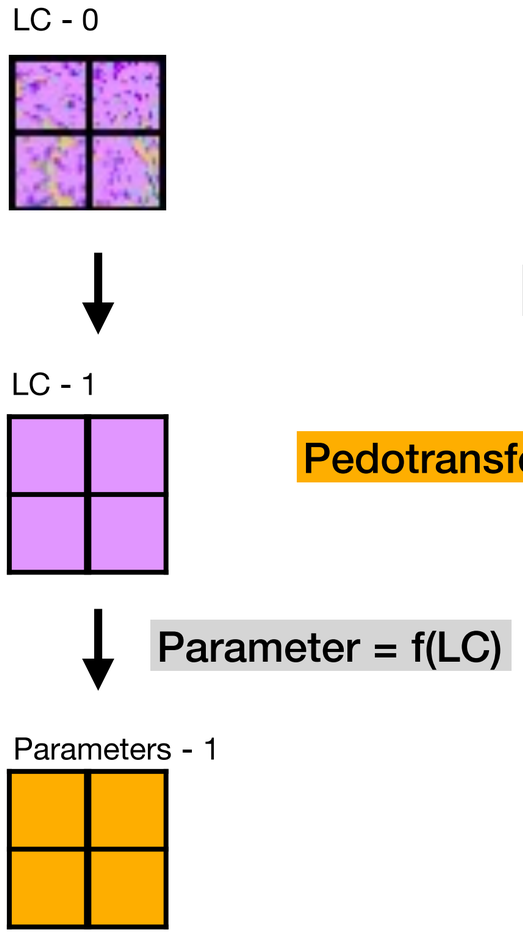
Kumar, R., Livneh, B., & Samaniego, L. (**2013**). Toward computationally efficient large-scale hydrologic predictions with a multiscale regionalization scheme. **Water Resources Research**, 49(9), 5700–5714. https://doi.org/10.1002/wrcr.20431

mHM 101
Multiscale Parameter Regionalisation

Option 1

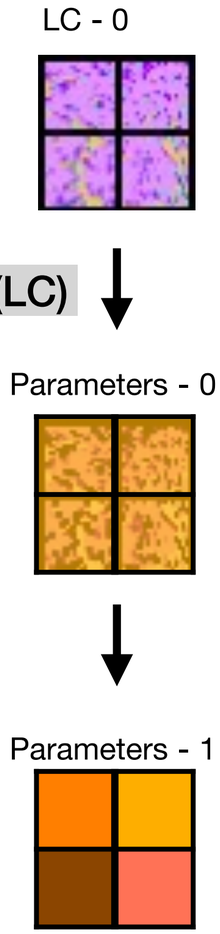
First Upscale the predictor variables from Level-0 to Level-1

Then get model parameter from predictor variables at Level-1



L0 variability LOST

Pedotransfer functions



L0 variability CONSERVED

Option 2

First get model parameter from predictor variables at Level-0

Then Upscale the parameter field from Level-0 to Level-1

FEEDBACK?

HOME

pallav-kumar.shrestha@ufz.de

@Pallav_Shrestha