EGU2020-6047

Towards scale independent hydrological forecasting in regulated semi-arid regions

Pallav Kumar **Shrestha***, Christof **Lorenz**, Husain **Najafi**, Stephan **Thober**, Oldrich **Rakovec**, Luis **Samaniego**

Funded by

Bundesministerium für Bildung und Forschung

Supporting project

SaWaM

UFZ HELMHOLTZ Centre for Environmental Research

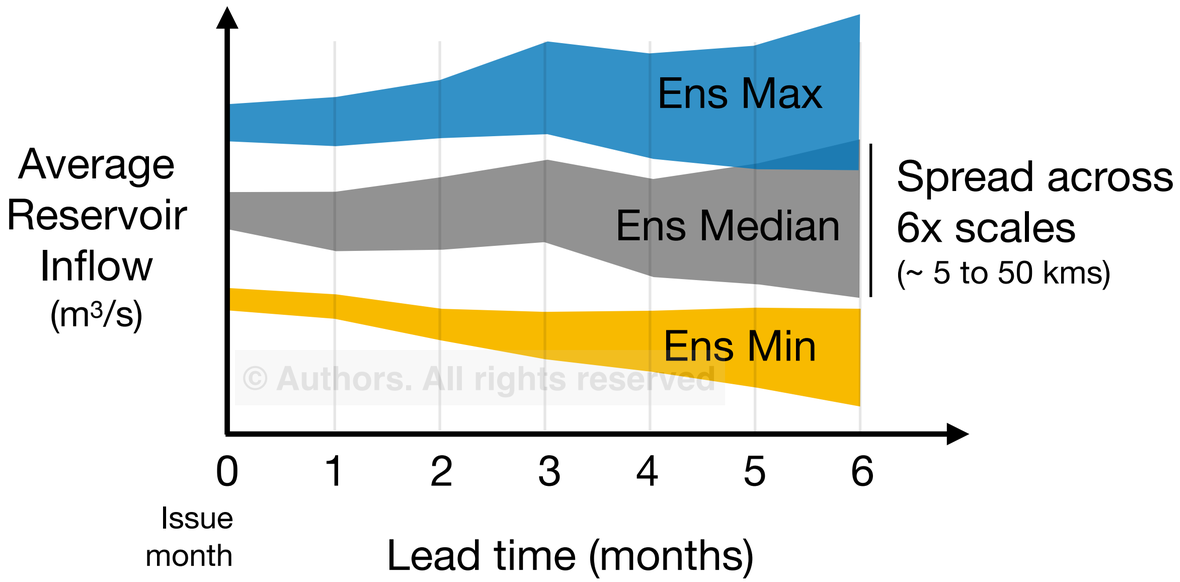
KIT Karlsruhe Institute of Technology Institute for Meteorology and Climate Research IMK-IFU

Research **Highlight**

We now have improved hydrological model (mHM) for **reduced forecast uncertainty across modeling scales** in regulated domains

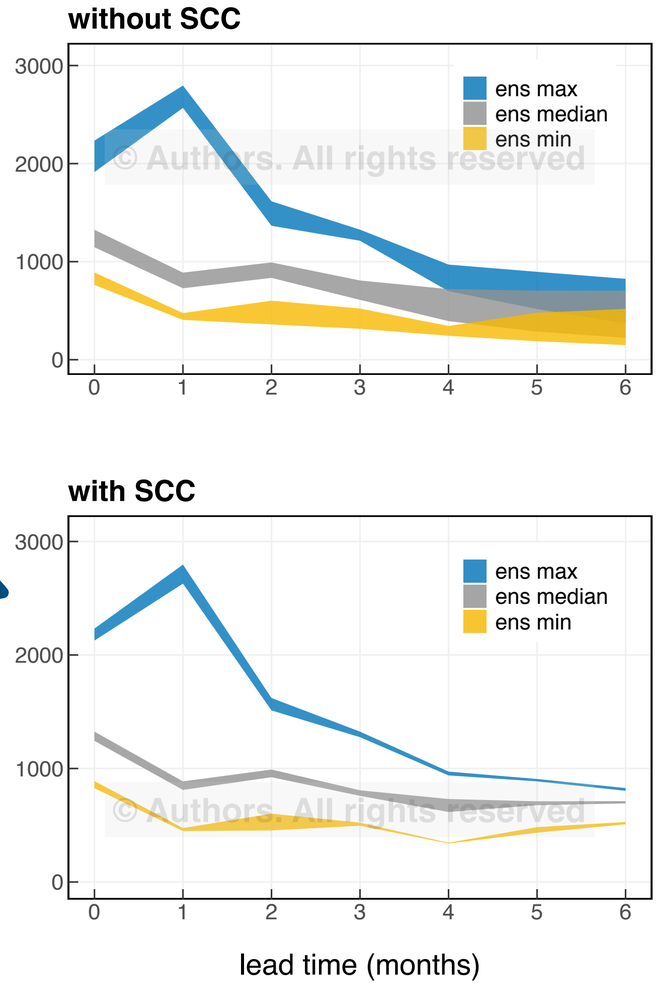
Note: Click here to directly jump to the Results slide!

GRAPH DEFINITION



Spread across the scales controlled!

Trés Marias (c.a. 50,816 km^2)



Background: Hydrological forecasts are imperative for semi-arid regions

Key hydro-anthropogenic features of **semi-arid**

- large fluctuations in annual precipitation
- seasonal storage and intensive use of water

SaWaM **WP3**

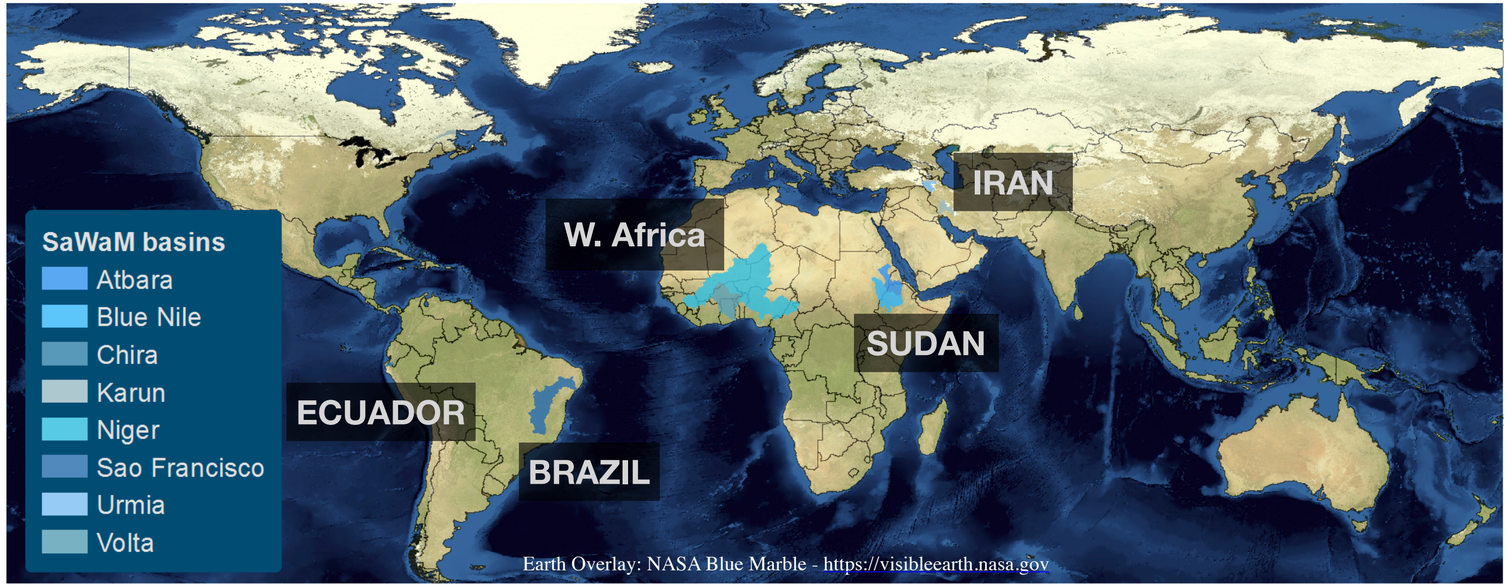
- **Seasonal hydrological forecasting system** with the meso-scale hydrological model (**mHM**)
- Reliable hydrological forecasts requires accurate representation of the existing lakes and reservoirs
- mHM is augmented with a new lake module for this task

The **Test**

- Are seasonal hydrological forecasts from the improved mHM scalable?

SaWaM Seasonal Water Management for Semi-Arid Areas

Funded by
Bundesministerium für Bildung und Forschung



Project: http://grow-sawam.org

Model: https://www.ufz.de/index.php?en=40114
https://git.ufz.de/mhm/mhm

Problem: The battle of lake size vs model resolution

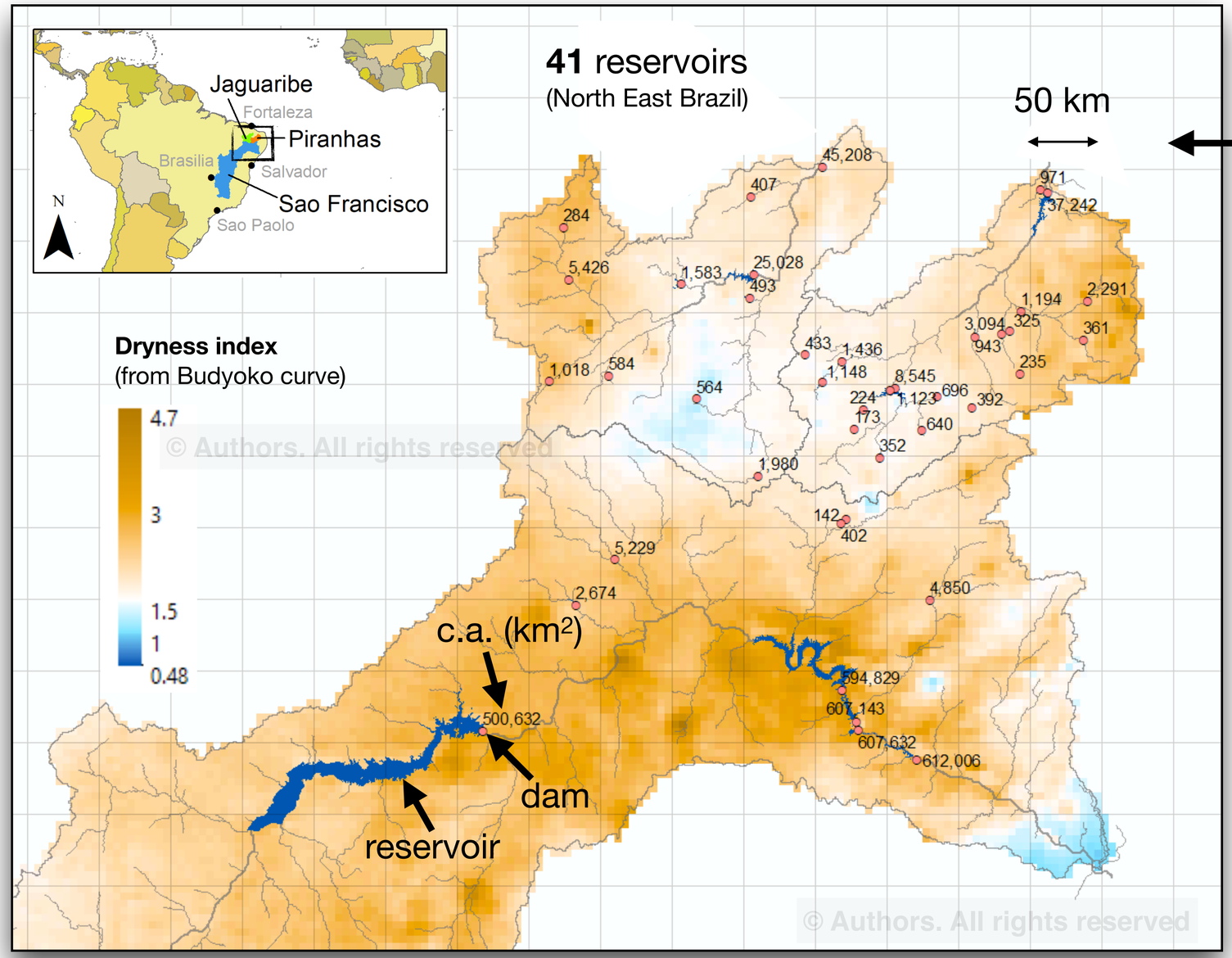


Figure.

São Francisco and its neighbouring basins to the North. The catchment area (c.a.) of reservoirs vary from 142 to 612,006 km² i.e. **four orders of magnitude!**

At 50 km model resolution, a lot of **reservoirs fall within the same grid**.

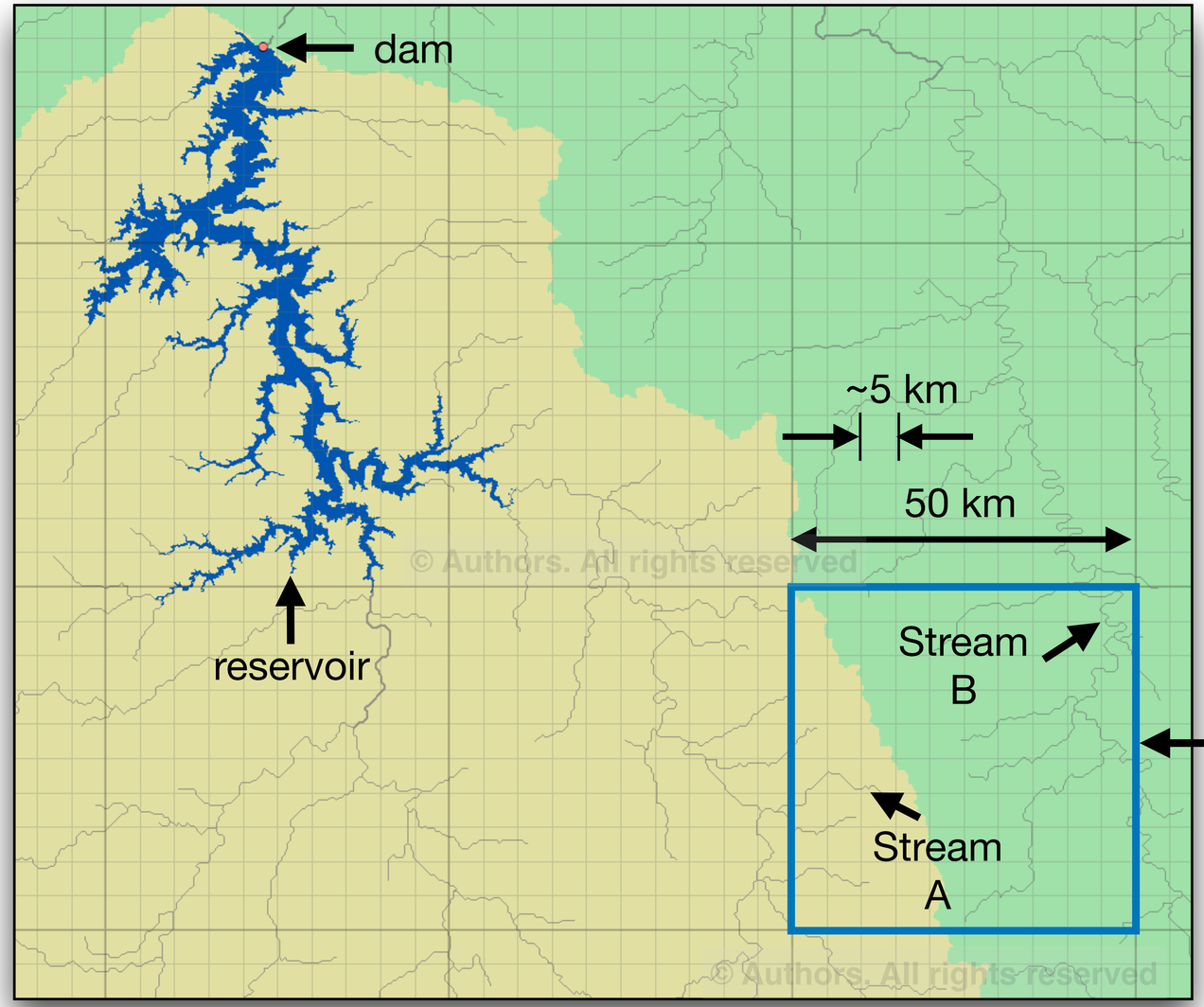
- ➡ Based on model resolution, lakes can be too small to be incorporated
- ➡ *Rephrase*: based on lake size, the model resolution can be too coarse

The **Problem**

- ➡ The “computational size” of lakes depends on model resolution. Lakes appear and disappear across resolutions. This shouldn’t happen!

c.a. : catchment area

Hypothesis: Preserve the contributing area info at Sub-grid!



In line with mesoscale hydrological model's (mHM) philosophy of conserving sub-grid information, we hypothesize the following -

The **Hypothesis**

"Sub-grid Catchment Contribution (SCC) based lake inflow routing will improve precision of reservoir inflow and consequently the forecast reliability across scales"

Example

At 50 km resolution, this region has one model cell. Stream B > Stream A. Without SCC, all water from this region is modelled to drain water away to the adjoining catchment. With SCC model fractionalizes the cell based on sub-grid catchment information (yellow and green).

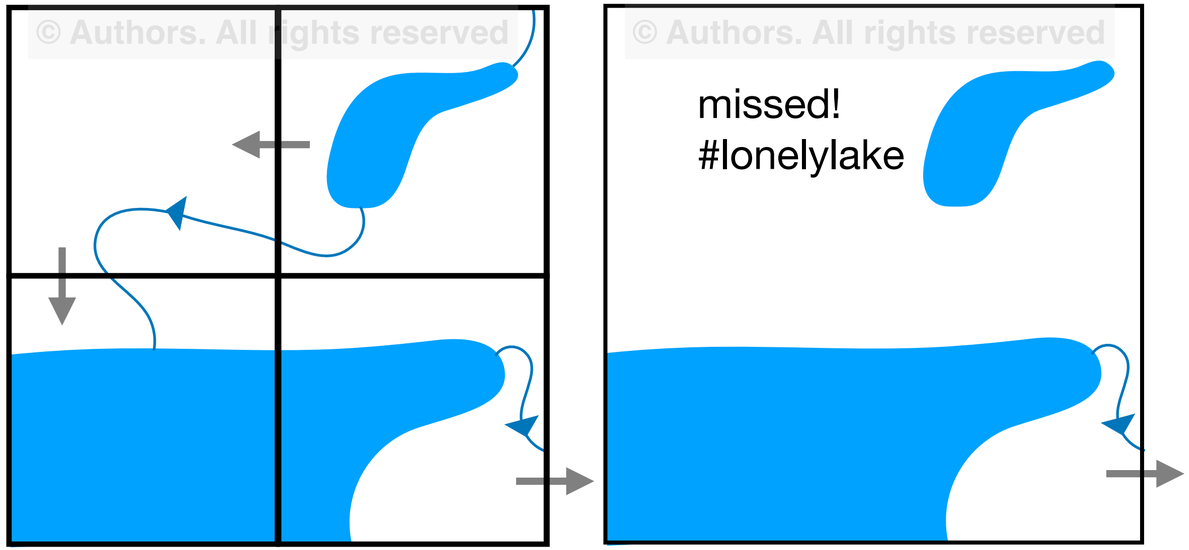
At ~5 km resolution, this regions has 100 model cells. Even without SCC, the model now is in better postion to accurately represent contributing area and reservoir inflow… but at a much larger computational expense!

Method: mHM - the model that scales with reservoirs

mesoscale Hydrological Model

PREVIOUSLY

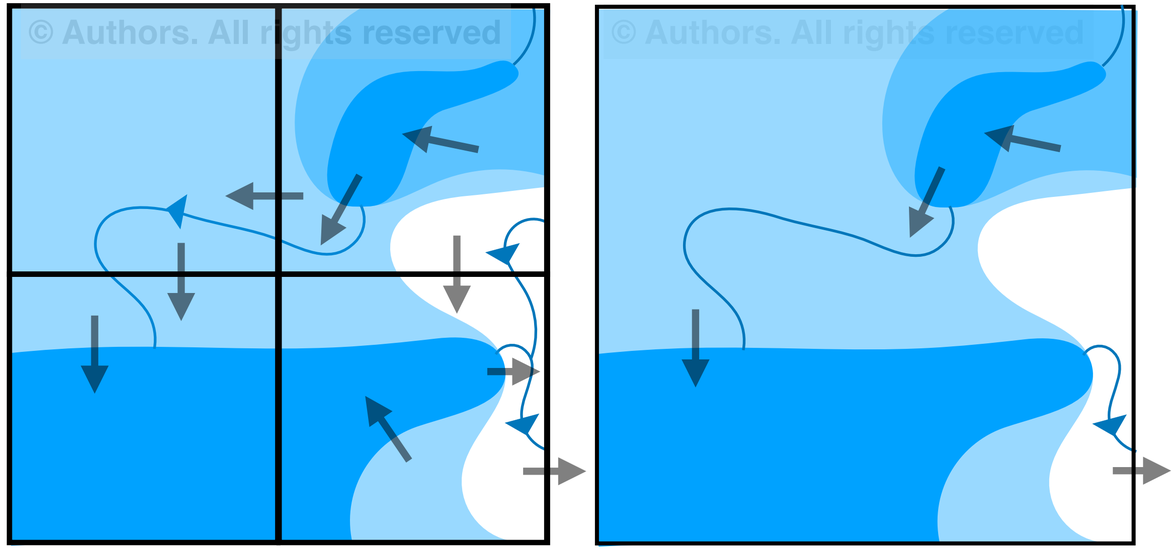
Routing based on main stream of the model grid cell



High model resolution | Low model resolution

NOW

Routing based on main stream of SCC fraction of each grid cell



High model resolution | Low model resolution

SCC - Sub-grid Catchment Contribution

Experiment - São Francisco basin, Brazil

2. Poco da Cruz (c.a. 4,850 km²)

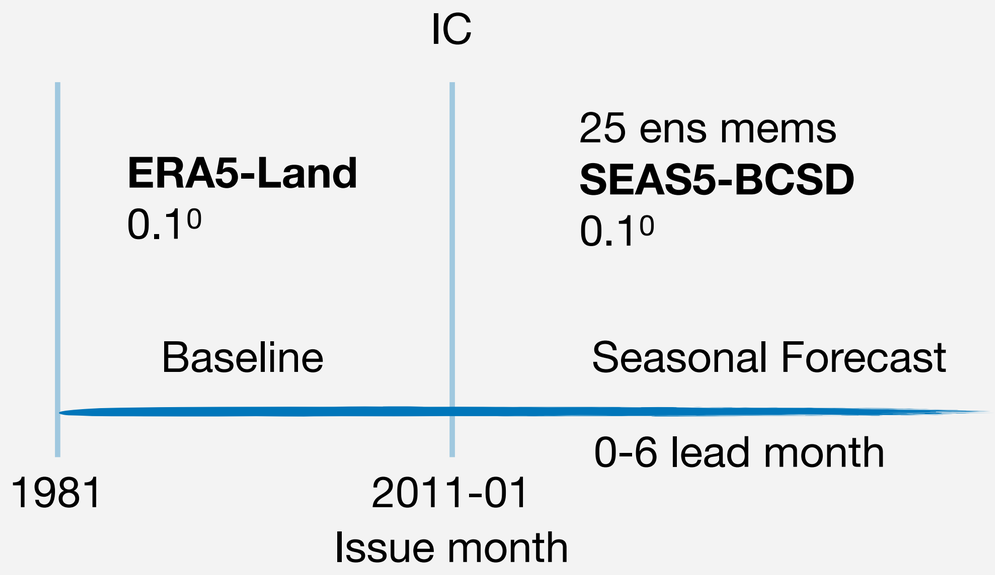
4. Sobradinho (c.a. 500,632 km²)
represents 60.4% of the hydroelectric power resources of the Northeast Brazil[1]

3. Trés Marias (c.a. 50,816 km²)
South America's first major hydroelectric power plant[2]

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

FORECASTING EXPERIMENT

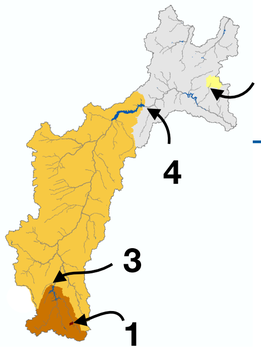
6x model resolutions
mHM 0.05^0, 0.10^0, 0.15^0, 0.20^0, 0.25^0, 0.50^0



SEAS5-BCSD - We bias corrected and spatially downscaled seasonal forecasts from its native 35km resolution to 0.1^0 using ERA5-Land

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

1 https://en.wikipedia.org/wiki/Sobradinho_Reservoir 2 https://en.wikipedia.org/wiki/Três_Marias_Dam



RESULTS - São Francisco basin, Brazil

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

! Model didn't resolve the small reservoir at 0.50⁰, 0.25⁰, 0.20⁰. 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

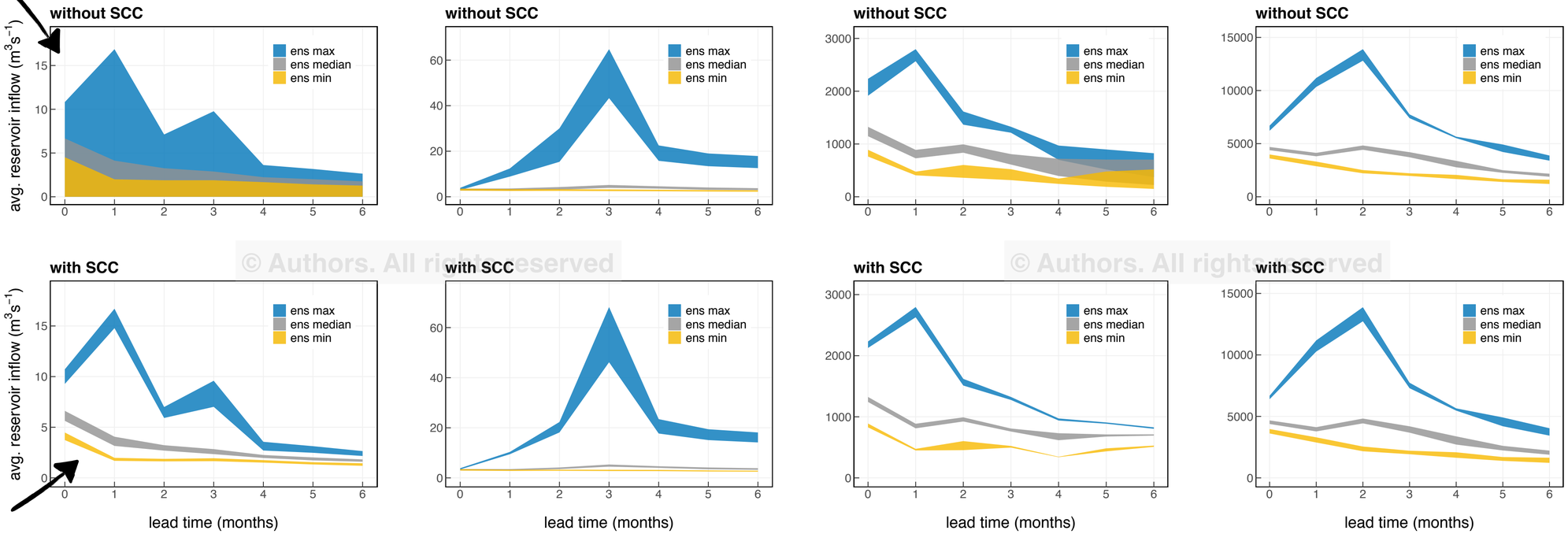
✓ Model correctly resolved the small reservoir at all resolutions incl. 0.50⁰

1 Serra Azul (c.a. 256 km^2)

2 Poco da Cruz (c.a. 4,850 km^2)

3 Trés Marias (c.a. 50,816 km^2)

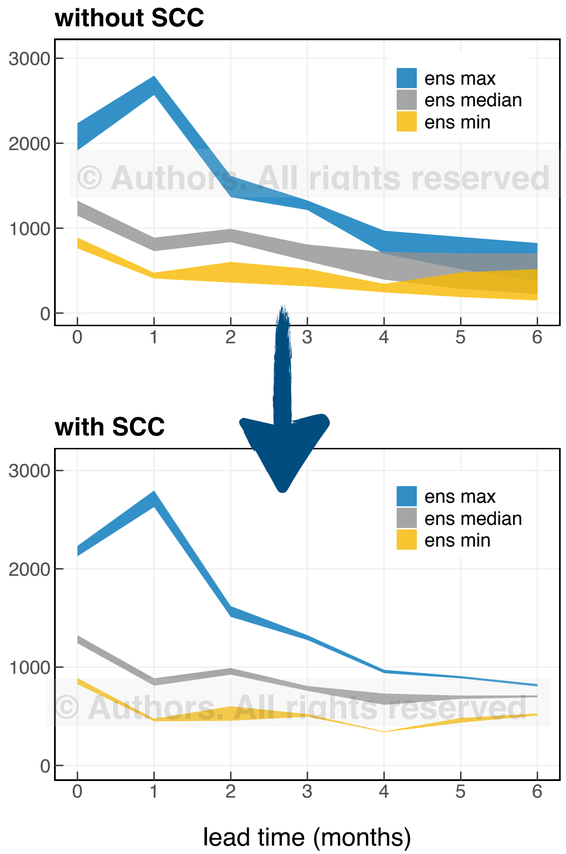
4 Sobradinho (c.a. 500,632 km^2)



Note: Click here to go to definition slide of this graph!

SUMMARY

Trés Marias (c.a. 50,816 km^2)



- The “computational size” of lakes *controls* the “modelled contributing area” producing inflow at a reservoir. Scalability with SCC in mHM helps to tackle this problem.
- We now have improved the mesoscale hydrological model (mHM) for **reduced forecast uncertainty across modeling scales** in regulated domains
- Scalability from **Sub-grid Catchment Contribution** is expected to help modellers in water resource management at all lake/ reservoir scales.

THANKS

CONTACT

pallav-kumar.shrestha@ufz.de

@Pallav_Shrestha

Bundesministerium
für Bildung
und Forschung