Application of Multiscale Parameterization Framework for the Large Scale Hydrologic Modeling

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1. Introduction

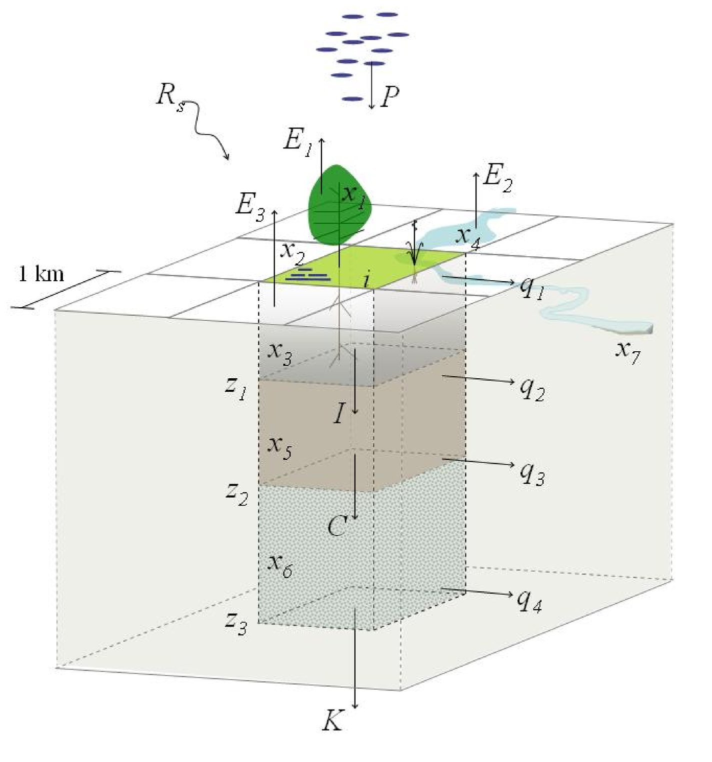
In recent decades there has been increasing interest in the development and application of large scale hydrologic models to support the management of regional water resources as well as for flood forecasting and drought monitoring. However, the reliable prediction of streamflow and other distributed hydrologic states (i.e. soil moisture, evapotranspiration) for large river basins (i.e. drainage area $> 10^5$ km^2) requires a robust parameterization technique that avoids scale dependent issues, reduces the over-parameterization problem, and allows the transferability of model parameters to unaguged locations.

2. Objectives

- To assess the performance of the distributed mesoscale hydrologic model (mHM) parameterized with a multiscale regionalization technique (MPR) in large scale river basins located in Europe and US.
- To test the feasibility of transferring *a priori* set of global parameters, estimated in a relatively small basin, to large river basins.
- To analyze the model performance for the cross-scale transferability of global parameters (i.e. to test the ability of mHM-MPR to operate at multiple spatial resolutions).

3. Mesoscale Hydrologic Model (mHM)[2, 1]

mHM is a grid based distributed hydrologic model which is parameterized with a multiscale regionalization technique that explicitly accounts for sub-grid variability of basin physical characteristics by linking them to model parameters at much finer spatial resolution (e.g. 100 – 500 m) than the model pixels (> 4 km).



State variable at cell i, time t

State equations: cell i, time t:

$$\dot{\mathbf{x}}_i(t) = \mathbf{f}(\mathbf{x}_i, \mathbf{u}_i, \boldsymbol{\beta}_i) + \boldsymbol{\eta}_i(t) \quad \forall i \in \Omega$$

Output: runoff:

$$\mathbf{q}_l(t) = \mathbf{g}(\mathbf{x}, \mathbf{u}, \boldsymbol{\beta}) + \boldsymbol{\epsilon}_l(t)$$

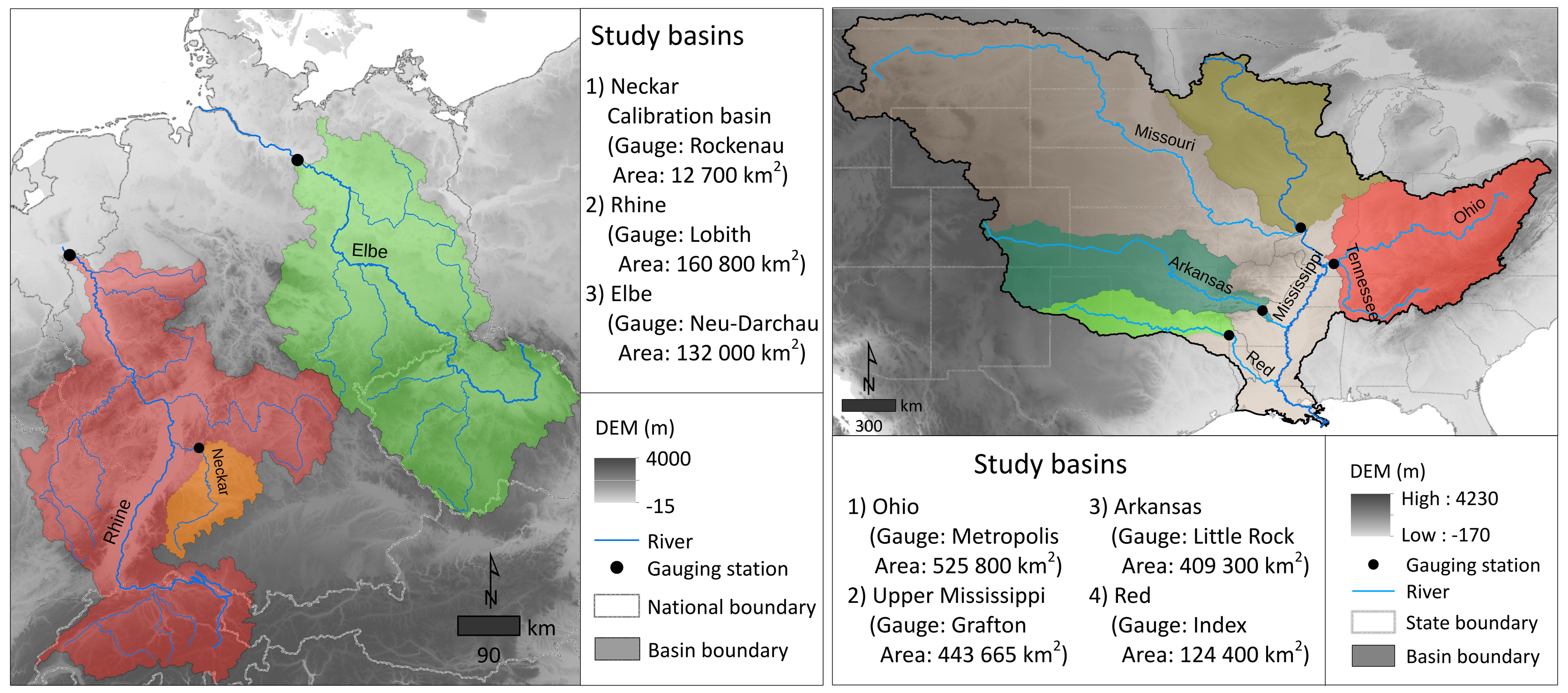
Multiscale parametrization[2]:

$$\beta_{ki}(t) = \mathrm{O}_k \left\langle \beta_{kj}(t) \quad \forall j \in i \right\rangle_i$$

$$\beta_{kj}(t) = \mathbf{w}_k\Big(\boldsymbol{u}_j(t), \boldsymbol{\gamma}\Big)$$

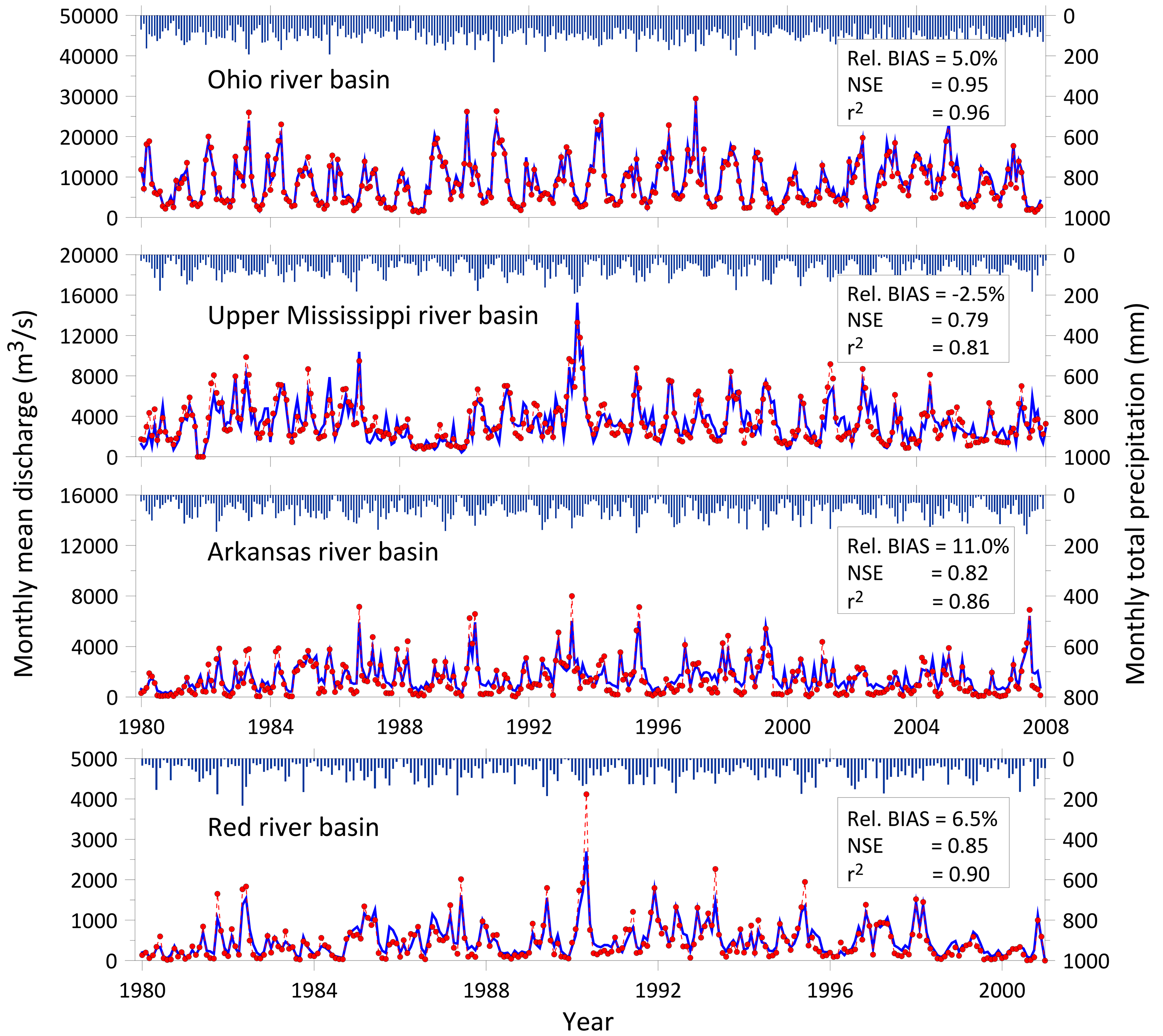
- $\mathbf{f}, \mathbf{g}$ system and output functional relationships
- $\mathbf{x}$ state variables
- $\mathbf{q}$ l-dimensional output vector
- $\mathbf{u}$ fields of physiographical and meteorological variables
- $\boldsymbol{\eta}$ unmeasurable stochastic inputs
- $\boldsymbol{\epsilon}$ system's uncertainty due to measurements defects
- Ω control volume (e.g. river basin)
- β distributed model parameter field
- γ global (or calibration) parameters
- w transfer or regionalization function
- O upscaling operators
- i, j cell location indexes at model grid and sub-grid levels
- k, t parameter and time indexes

4. Study Areas



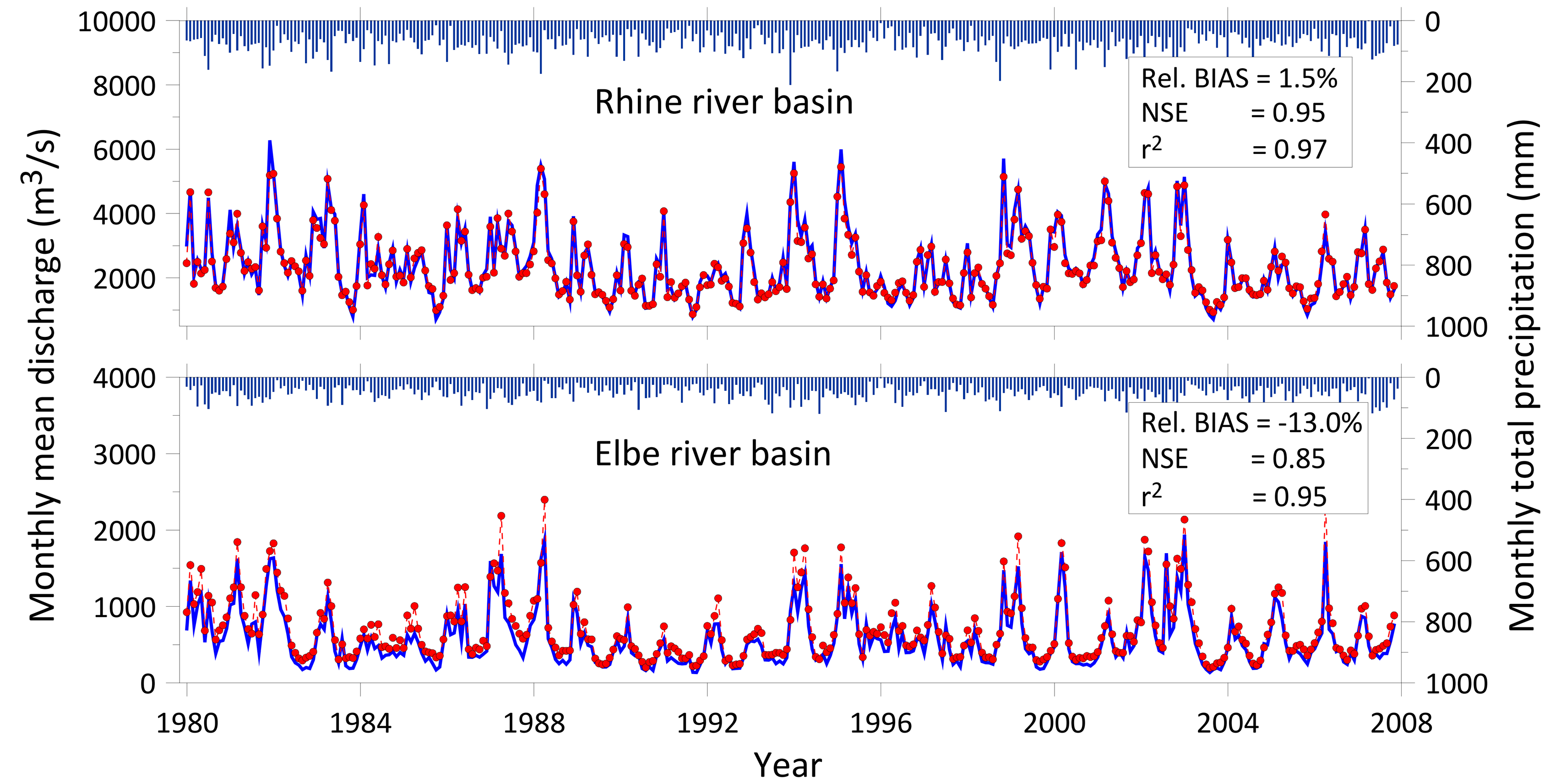
5. Model Performance in US River Basins

Model simulations were performed at 0.125° (≈12.5 km) spatial resolution using a set of parameters estimated in the Neckar river basin.

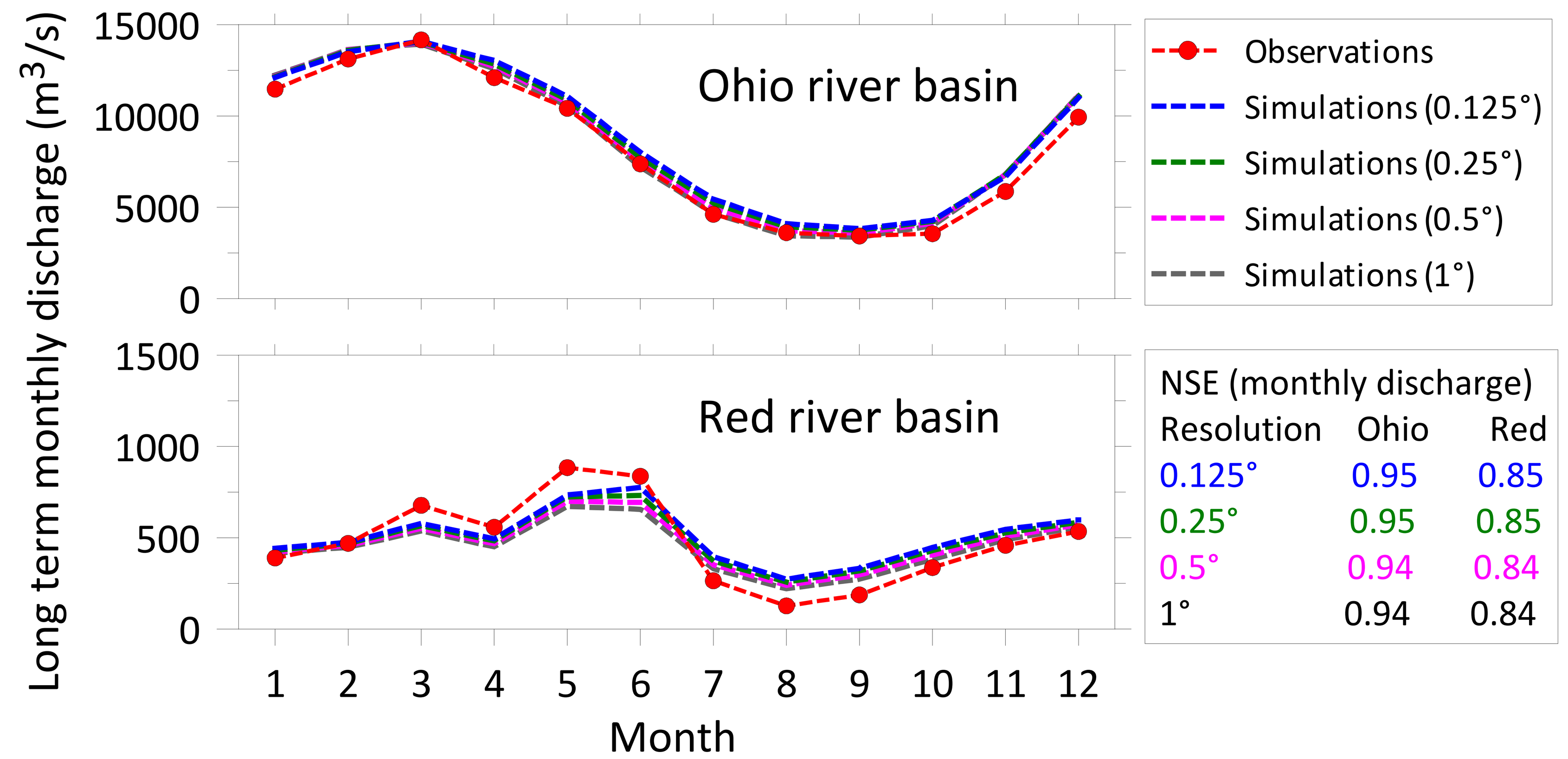


6. Model Performance in European River Basins

Model simulations were performed at 8 km spatial resolution using a set of parameters estimated in the Neckar river basin.



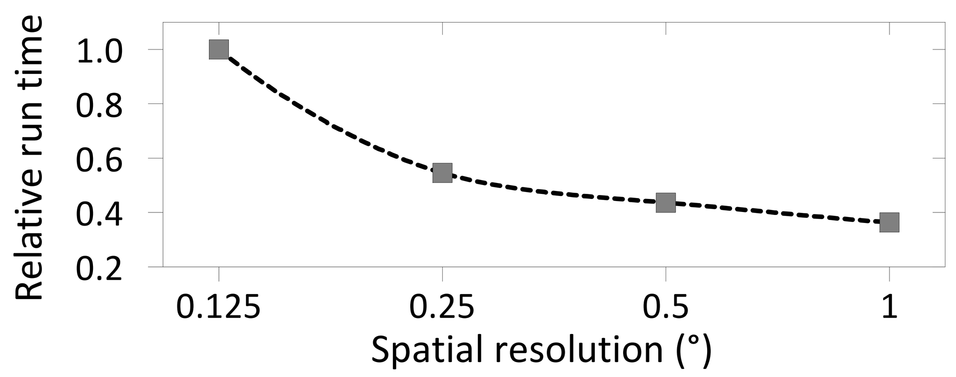
7. Model Performance at Multiple Spatial Resolutions



NSE (monthly discharge)

Resolution	Ohio	Red
0.125°	0.95	0.85
0.25°	0.95	0.85
0.5°	0.94	0.84
1°	0.94	0.84

8. Computational Load of Model Runs



Study basin: Ohio

Simulation period: 1 year

Temporal resolution: 3 h

Actual run time at 0.125° resolution is ≈ 8 minutes on the UFZ-EVE cluster

9. Conclusions and Outlooks

- The mHM model parameterized with MPR is able to simulate the discharge dynamics of large river basins very well.
- The transferability of global parameters of mHM-MPR to scales and locations other than those used during their calibration is possible.
- Our ongoing work focus on analyzing the mHM simulations for other hydrological states and fluxes, as well as their comparisons with other well established models.

References

[1] R. Kumar, L. Samaniego, and S. Attinger, "Implications of distributed hydrologic model parameterization on water fluxes at multiple scales and locations," *Water Resour. Res.*, 2012 (in press).

[2] L. Samaniego, R. Kumar, and S. Attinger, "Multiscale parameter regionalization of a grid-based hydrologic model at the mesoscale," *Water Resour. Res.*, p. W05523, 2010.

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