Multi-criteria hydrologic parameterization over European river basins

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1. Introduction

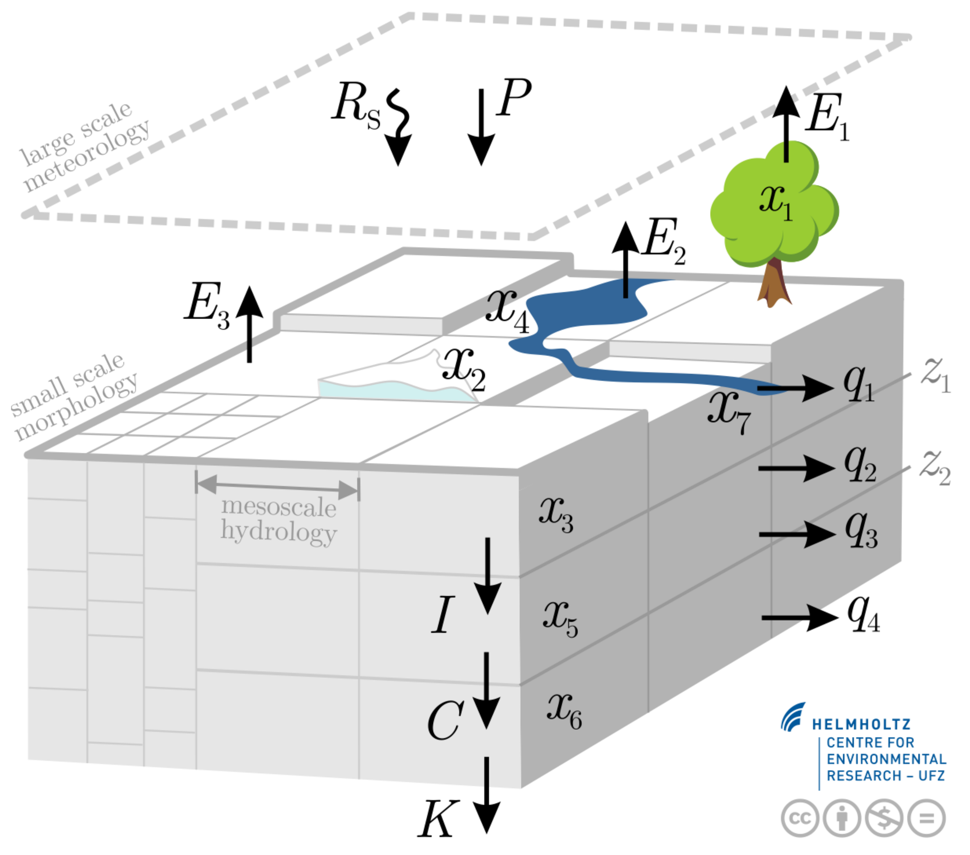
Understanding hydrologic model uncertainty and meaningful representation of hydrological processes leads to more reliable hydrologic forecasts, which can be in particular critical under extreme hydrometeorologic conditions. Therefore, hydrologic model development and evaluation should not only focus on the simulated streamflow (model output), but also on other key hydrological variables, such as total water storage.

Objective

The objective is to assess the benefits of multi-criteria calibration for 8 large European basins. Besides traditional calibration of hydrologic model against observed discharge (Q), model parameters are additionally constrained by the GRACE terrestrial total water storage (TWS) observations.

2. The Mesoscale Hydrological Model (mHM)

The mesoscale hydrologic model (mHM) used in this study is a grid based distributed model that is based on numerical approximations of dominant hydrologic processes similar to those applied in models such as the HBV and the VIC. The model is open source and can be downloaded from `www.ufz.de/mhm`. It employs the multiscale parameter regionalization (MPR) technique to efficiently incorporate the sub-grid information to generate scale independent parameterization (*Samaniego et al*, 2010).

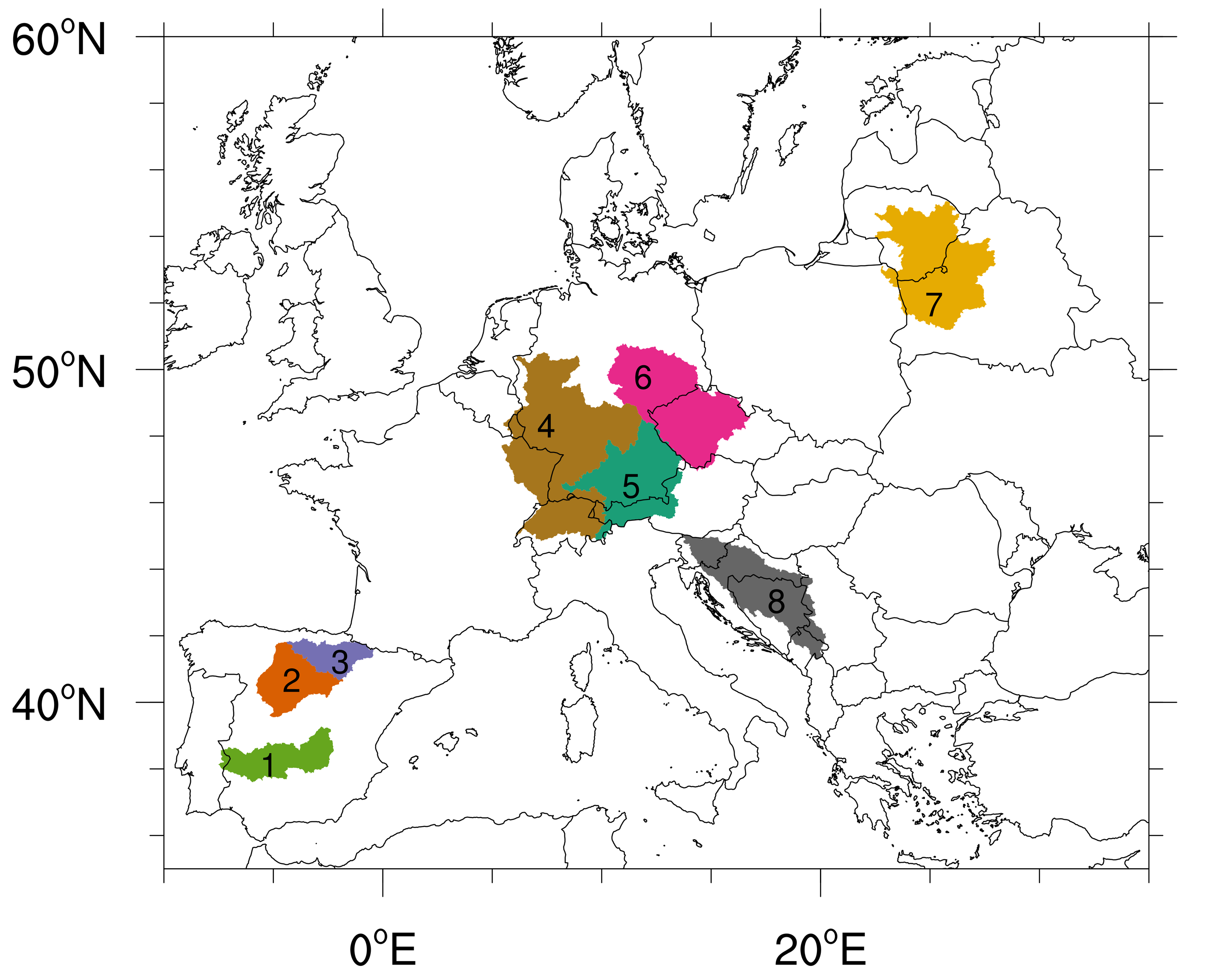


$$Q_t = \sum_{i=1}^{K} q_{t,i}$$

$$TWS_t = \sum_{i=1}^{L} x_{t,i} - \frac{1}{T}\sum_{t=1}^{T}\sum_{i=1}^{L} x_{t,i}$$

Samaniego L., R. Kumar, S. Attinger (2010): Multiscale parameter regionalization of a grid-based hydrologic model at the mesoscale. *Water Resour. Res.*, **46**, W05523.

3. Study areas



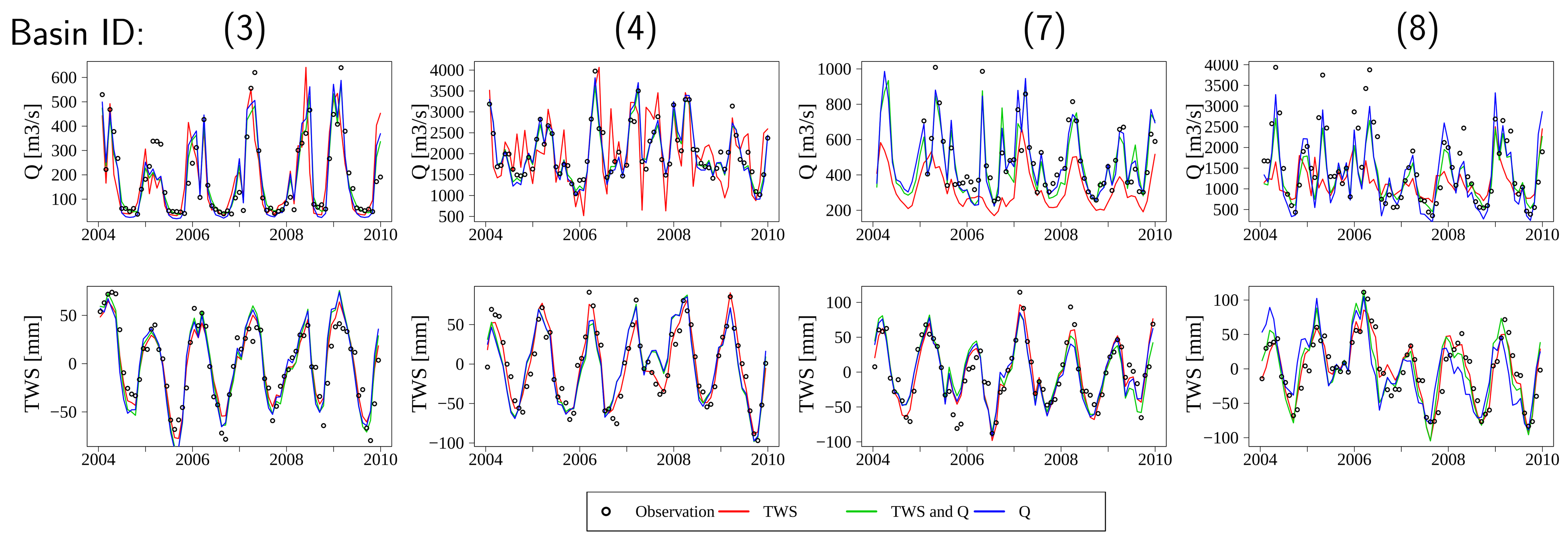
The analysis is carried out for 8 large European basins and evaluated in terms of model performance against (1) observed discharge (Q) and (2) observed total water storage anomaly (TWS).

ID	River Name (Station Name)	Area (km^2)
1	Guadiana River (Azud de Badajoz)	48 500
2	Duero River (Zamora)	46 000
3	Ebro River (Castejon)	25 000
4	Rhine River (Lobith)	160 000
5	Danube River (Achleiten)	77 000
6	Elbe River (Magdeburg)	95 000
7	Nemunas River (Smalininkai)	81 000
8	Sava (Sremska Mitrovica)	88 000

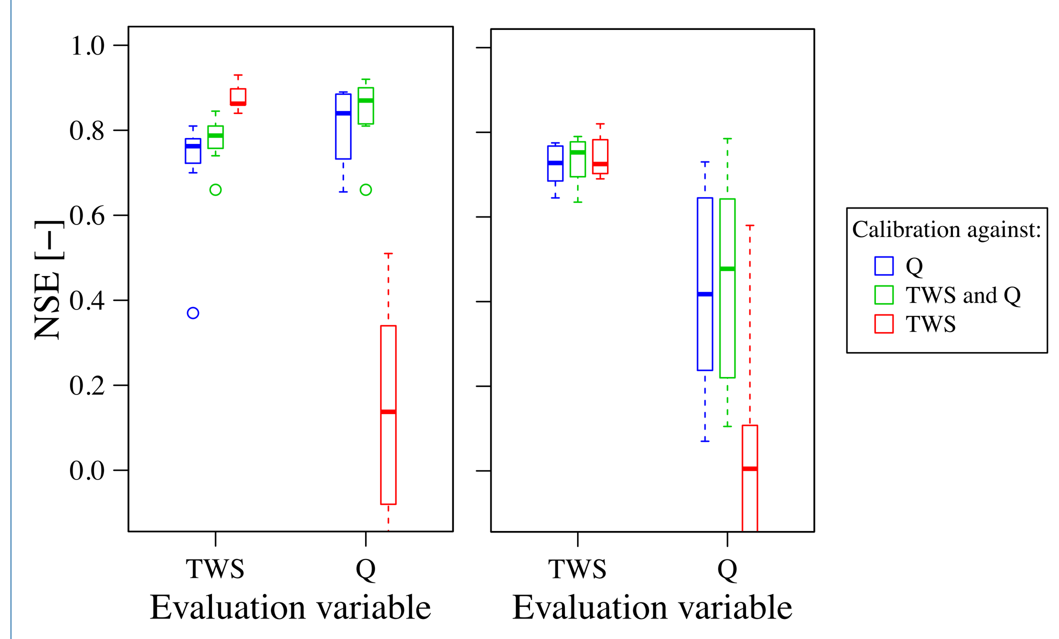
4. Experimental Setup

- Calibration consists of three scenarios:
  - Discharge (Q)
  - Discharge and total water storage anomaly (Q and TWS)
  - Total water storage anomaly (TWS)
- Calibration period: 1 January 2004 – 31 December 2009
- Objective function: Nash-Sutcliffe model efficiency (NSE)
- Time step: Q (daily) and TWS (monthly)
- Spatial resolution: 1° × 1°
- Meteorological forcings derived from E-OBS
- Calibration algorithm: DDS
- Independent evaluation of parameter transferability

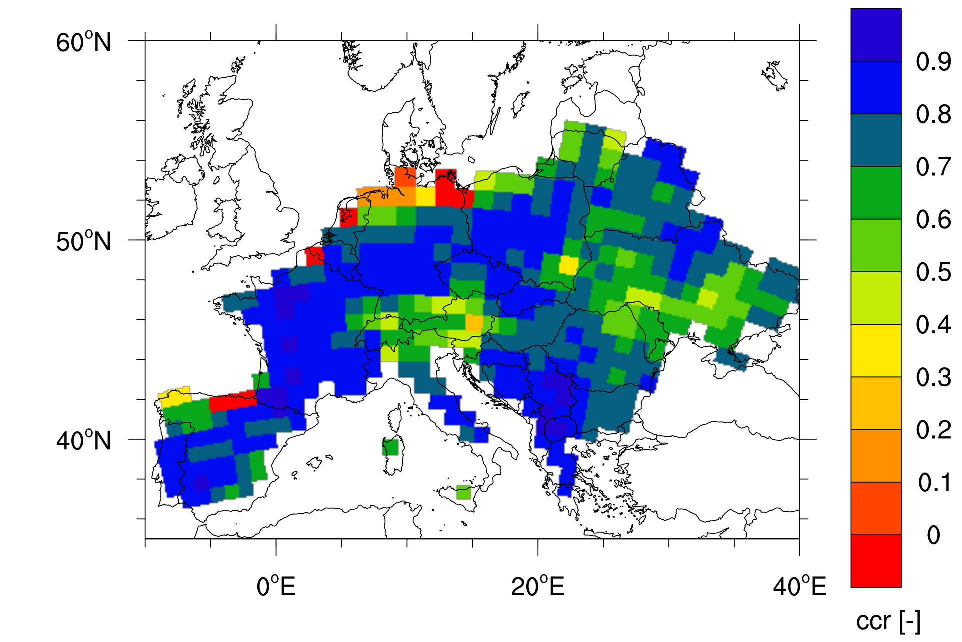
5. Results



Time series for Q (top) and TWS (bottom) for the three calibration scenarios.



Summary performance for the at-site calibrations (left, 8 basins) and model evaluations at the other locations (right, other 7 basins).



Pearson correlation between model and GRACE across the entire domain using the TWS and Q parameterization.

6. Conclusions

- Initial results show that constraining model parameters with complementary data set such as total water storage (TWS) anomaly can lead to improvement in discharge prediction (including evaluation in other basins).
- Calibration against TWS alone is not enough to infer discharge dynamics.
- mHM parameterization is robust to TWS when evaluated at other locations.

Discharge data were obtained from the Global Runoff Data Centre (GRDC). We acknowledge the E-OBS dataset from the EU-FP6 project ENSEMBLES (http://ensembles-eu.metoffice.com) and the data providers in the ECA&D project (http://www.ecad.eu). GRACE land data (available at http:// grace.jpl.nasa.gov) processing algorithms were provided by Sean Swenson, and supported by the NASA MEaSUREs Program.

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