

# Towards robust predictions of water fluxes and states on large scales

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## Abstract

Finding cost effective solutions to pressing environmental problems or reducing the vulnerability of socio-economic activities to extreme hydro-meteorological events require among other things to be able to monitor and predict the movement of water on the landscape at scales of 1 to 5 km. Limited data availability, on the other hand, imposes another grand challenge because most hydrological predictions would have to be done in ungauged locations. As a consequence of these requirements and limitations land surface and distributed hydrological models are fraught with issues such as over-parameterization, parameter non-identifiability, non-transferability of parameters across calibration scales and locations, and demanding computational time.

Solutions to these grand challenges require explicit schemes that allow existing models to exploit all existing physiographical, meteorological, and remotely sensed data within a formal hypothesis testing framework.

In this study, the predictive uncertainty of the distributed mesoscale Hydrological Model (mHM) was investigated in eight major river basins in Germany (Danube, Main, Weser, Neckar, Mulde, Ems, Saale, Rhine) and two river basins in the USA (Red River and Ohio). In Germany, mHM is forced with (4 x 4) km daily precipitation and temperature fields interpolated from 5600 rain gauges and 1100 meteorological stations operated by the German Meteorological Service (DWD). In the USA, this model was forced with NLDAS-2 data set.

Within this framework the effects of scale, transferability of parameters across scales and locations, data uncertainty, sub-grid variability of parameters as well as the effects of the kind of estimators or objective functions on model outputs such as discharge, upper layer soil moisture, and groundwater recharge were investigated. All analysis were carried out with two parametrization methods: hydrologic (homogeneous) response units (HRU) and a multiscale parameter regionalization technique (MPR).

Results indicated that modeled water fluxes are extremely sensitive to the parameterization method employed as well as the sub-grid variability of the parameter fields. HRU is scale dependent whereas MPR is almost scale invariant. Regarding model parameters, discharge and soil moisture are quite sensitive to those parameters related with the soil texture such as soil porosity and recession constants. Discharge is also extremely sensitive to routing parameters. Extreme high-flow events are highly sensitive to initial soil moisture conditions, which in turn is quite sensitive to land cover changes.