EGU26-11049, updated on 08 Jun 2026
https://doi.org/10.5194/egusphere-egu26-11049
EGU General Assembly 2026

Multi-variable validation and calibration of the mesoscale Hydrologic Model (mHM) using independent observations of the soil water balance

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Distributed hydrological models such as the mesoscale Hydrologic Model (mHM) are commonly calibrated against discharge observations, implicitly assuming that good agreement with discharge reflects a realistic representation of internal states and fluxes. However, discharge-only calibration may lead to parameter equifinality and insufficiently constrained simulations of soil moisture, evapotranspiration, and groundwater recharge. This limits the interpretability of model results for drought analysis, water balance assessment, and management-oriented applications.

Within the MOWAX ("Monitoring- and modelling concepts as a basis for wate rbudget assessments in Saxony") project, we assess the consistency of the simulated soil water balance of mHM using a comprehensive, multi-variable validation framework for Saxony (Germany). To better represent regional soil heterogeneity, the model setup incorporates high-resolution soil information based on the BK50 soil map. Model outputs are evaluated against independent observational data sets representing all major components of the terrestrial water balance across different spatial and temporal scales. These include observed discharge at multiple gauging stations, estimates of actual evapotranspiration derived from eddy-covariance measurements at ICOS sites and gridded Fluxcom products, long-term mean groundwater recharge from an independent BGR raster data set, and area-representative soil moisture observations from a Cosmic-Ray Neutron Sensing (CRNS) station at Cunnersdorf.

We conduct a conventional calibration of mHM using discharge observations only and select parameter sets that achieve high runoff performance. These parameter sets are subsequently evaluated with respect to their ability to reproduce independently observed soil moisture dynamics, evapotranspiration patterns, and groundwater recharge estimates. This step explicitly tests whether good discharge performance coincides with physically plausible internal model behavior. First results suggest that discharge-only calibration can be associated with a large spread in simulated soil moisture states despite similarly good runoff performance. The inclusion of soil moisture information as an additional constraint appears to reduce this spread and to improve the consistency of simulated soil water storage dynamics. However, the degree to which these constraints translate into improved agreement with independent evapotranspiration and

groundwater recharge estimates is explicitly assessed and discussed.

The MOWAX project is funded by the European Regional Development Fund (EFRE) and by tax revenue on the basis of the budget approved by the Saxon state parliament (funding code 100702604).