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An open-source distributed mesoscale hydrologic model (mHM)

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The mesoscale hydrological model (mHM) is based on numerical approximations of dominant hydrological processes that have been tested in various hydrological models such as: HBV and VIC. In general, mHM simulates the following processes: canopy interception, snow accumulation and melting, soil moisture dynamics (n-horizons), infiltration and surface runoff, evapotranspiration, subsurface storage and discharge generation, deep percolation and baseflow, and discharge attenuation and flood routing. The main characteristic of mHM is the treatment of the sub-grid variability of input variables and model parameters which clearly distinguishes this model from existing precipitation-runoff models or land surface models. It uses a Multiscale Parameter Regionalization (MPR) to account for the sub-grid variability and to avoid continuous re-calibration. Effective model parameters are location and time dependent (e.g., soil porosity). They are estimated through upscaling operators that link sub-grid morphologic information (e.g., soil texture) with global transfer-function parameters, which, in turn, are found through multi-basin optimization. Global parameters estimated with the MPR technique are quasi-scale invariant and guarantee flux-matching across scales.

mHM is an open source code, written in Fortran 2003 (standard), fully modular, with high computational efficiency, and parallelized. It is portable to multiple platforms (Linux, OS X, Windows) and includes a number of algorithms for sensitivity analysis, analysis of parameter uncertainty (MCMC), and optimization (DDS, SA, SCE). All simulated state variables and outputs can be stored as netCDF files for further analysis and visualization.

mHM has been evaluated in all major river basins in Germany and over 80 US and 250 European river basins. The model efficiency (NSE) during validation at proxy locations is on average greater than 0.6. During last years, mHM had been used for number of hydrologic applications such as, for example, a) to investigate the influence of the antecedent soil moisture on extreme floods in Germany (2002 and 2013), b) for establishing benchmark agricultural drought events for Germany since 1950. A 60-year reconstruction of the daily mHM soil moisture fields over Germany at high resolution 4×4 km^2 was used for this purpose, and c) to investigate the potential benefits of a high resolution modeling approach for the drought monitoring and forecasting system over Pan-EU. We invite the community to take advantage of this open-source code which is freely available (after nominal registration) at: http://www.ufz.de/index.php?en=31389.