

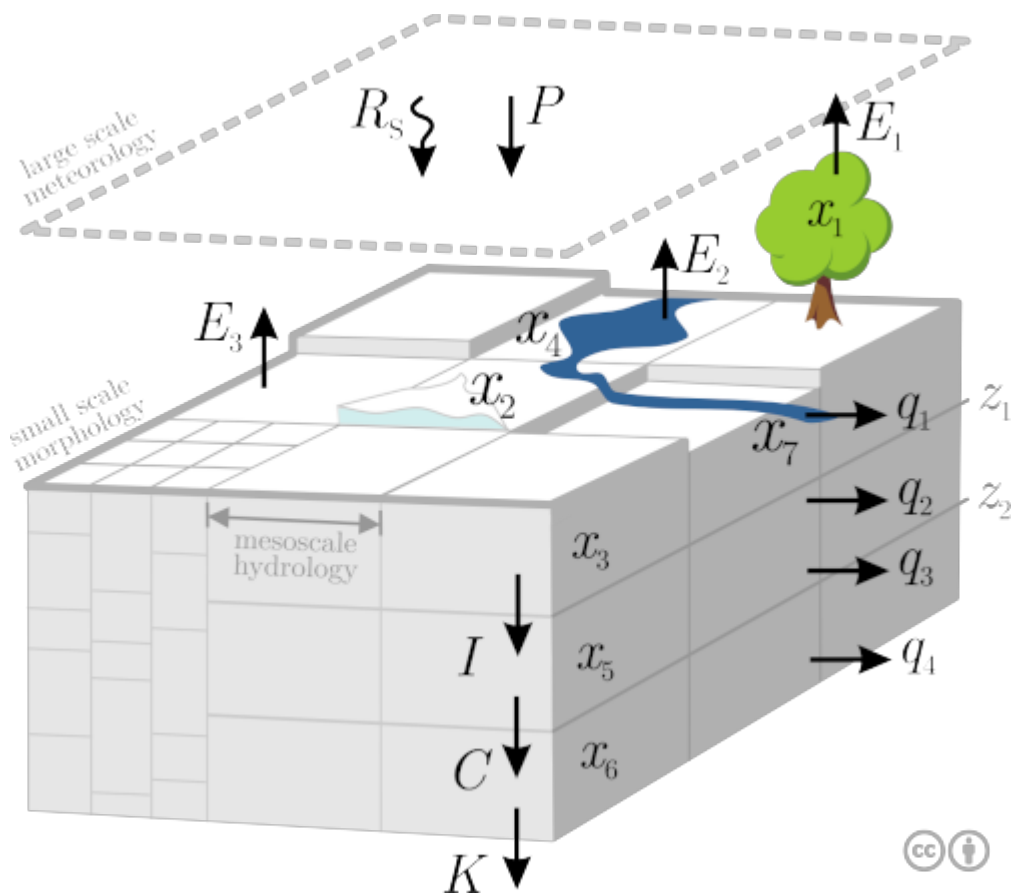


The mesoscale Hydrologic Model mHM v6 – the next generation: Modular, Extensible, and Scalable Hydrological Modeling

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The mesoscale Hydrologic Model (mHM), first released in 2010, is today used both to advance process understanding and to provide operational services for the water sector and the wider public (e.g. the German drought monitor). mHM v5, released in 2014, established a highly modular hydrologic modeling framework. Here, we present mHM v6 – the next-generation mHM release, addressing key limitations of mHM v5 in three areas:

1. **Modularity:** While mHM v5 offered multiple implementations of individual processes, it was not possible to run selected components in isolation (e.g., soil-water dynamics, runoff generation, or routing). mHM v6 expands the stand-alone usage of core components, enabling workflows such as routing externally provided runoff fields (e.g., from observations, reanalyses, or other models) without requiring a full mHM hydrologic simulation. This lowers the barrier for targeted studies and supports multi-model intercomparisons.

2. **Extensibility:** mHM v5 provided Python bindings to access internal state variables and parameters, allowing users to manipulate these during runtime (e.g., for data assimilation, sensitivity analyses, and experimentation). mHM v6 strengthens coupling capabilities via coupling frameworks such as YAC and FINAM, complemented by Python bindings for flexible orchestration and prototyping. In addition, mHM v6 introduces a redesigned internal code structure based on object-oriented design, simplifying the addition of new process options (e.g., alternative vegetation representations) and new process components.

3. **Scalability:** mHM v6 introduces a revised routing framework based on a directed acyclic graph (DAG) representation of the river network with built-in OpenMP parallelization. This enables efficient simulations on increasingly large and high-resolution river networks, supporting applications from regional to continental and global scales.

Beyond these core developments, mHM v6 integrates and harmonizes several recent extensions into a unified modeling workflow. This includes floodplain simulation within the routing network, explicit representation of lakes and reservoirs, and subgrid catchment conservation (SCC) options to represent catchments smaller than the grid size while conserving points of interest (e.g., streamflow gauges and dams). On the land-surface side, mHM v6 incorporates a Richards-equation-based approach for soil infiltration, solved with an efficient numerical scheme (Ross' fast method).

We demonstrate mHM v6 through (i) global river-network routing experiments based on the MERIT Hydro river network, quantifying the performance gains from the new parallel routing scheme, and (ii) a standalone routing setup driven by externally provided runoff to illustrate component-level workflows. We further outline how the same routing component can be embedded into coupled modeling chains via YAC/FINAM and Python-based orchestration. Overall, mHM v6 positions mHM as both a community hydrologic model and a reusable building block for modern, integrated, and scalable hydrologic workflows.

Website: <https://mhm-ufz.org/>

Papers describing mHM

- Samaniego et al 2010: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2008WR007327>
- Kumar et al 2013: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2012WR012195>