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mRM - multiscale Routing Model for Scale-Independent Streamflow Simulations

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Routing streamflow through a river network is a basic step within any distributed hydrologic model. It integrates the generated runoff and allows comparison with observed discharge at the outlet of a catchment.

The Muskingum routing is a textbook river routing scheme that has been implemented in Earth System Models (e.g., WRF-HYDRO), stand-alone routing schemes (e.g., RAPID) , and hydrologic models (e.g., the mesoscale Hydrologic Model - mHM). Two types of implementations are mostly used. In the first one, the spatial routing resolution is fixed to that of the elevation model irrespective of the hydrologic modeling resolution. This implementation suffers from a high computational demand. In the second one, the spatial resolution is always applied at the hydrologic modelling resolution. This approach requires a scale-independent model behaviour which is often not evaluated.

Here, we present the multiscale Routing Model (mRM) that provides a flexible choice of the routing resolution independent of the hydrologic modelling resolution. It incorporates a triangular unit hydrograph for overland flow routing and a Muskingum routing scheme for river routing. mRM provides a scale-independent model behaviour by exploiting the Multiscale Parameter Regionalisation (MPR) included in the open-source mHM (www.ufz.de/mhm). MPR reflects the structure of the landscape within the parametrisation of hydrologic processes. Effective model parameters are derived by upscaling of high-resolution (i.e., landscape resolution) parameters to the hydrologic modelling/routing resolution as proposed in Samaniego et al. 2010 and Kumar et al. 2013.

mRM is coupled in this work to the state-of-the-art land surface model Noah-MP. Simulated streamflow is derived for the Ohio River ($\approx$ 525 000 km^2) during the period 1990-2000 at resolutions of 0.0625º, 0.125º, 0.25º and 0.5º. The NSE between the simulations at 0.0625º and 0.5º is 0.94, implying very good scaling capabilities of mRM. A similar scaling behaviour is observed for the Rhine river basin ($\approx$ 185 000 km^2) highlighting the applicability of mRM under different hydro-climatic conditions. The multiscale Routing Model mRM is thus suitable for coupling to hydrologic and land surface models, simulating on very different spatial resolutions. It can be applied as an offline post-processing tool but provides also easy capabilities for online coupling, for example for model calibration against river discharge.

References:

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