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An open source toolkit for the implementation of hypotheses driven, integrated water and solute fate models

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Hydrological models are composed of hypotheses concerning the flow regime in the landscape. Classical model applications do not test these implicit hypotheses, but solely calibrate the parameter set of this single model structure. This more or less blind use of modeling systems has been critically disputed in the last decade, due to the lack of a hypotheses guided methodology. Modular frameworks can help to formulate, implement and test hypotheses. The Catchment Modelling Framework, CMF, is such a modular framework, designed to be openly accessible and operating system independent. CMF is implemented in C++ as a library of objects for the design of problem oriented, catchment specific model structures. The objects of the library are assembled with the programming language Python, utilizing the vast amount of available scientific libraries. The model domain is discretized following a finite volume approach. Models are created as a web of water fluxes, where the finite volumes (water storages) and boundary conditions form the nodes, and equations for water fluxes (flux connections) form the edges. Using these objects as a model toolkit, a large range of different models can be realized: from physics based one dimensional percolation models, over two dimensional hillslope models to large scale lumped or semi-distributed approaches. Distinct hydrological features, like irrigation or drainage measures can be included into the model as additional flux connections.

Due to the open interface of CMF, high frequency exchange of data with additional models can be implemented. By coupling models in depth with this mechanism, driven by a shared steering script, new integrated approaches are rapidly developed. This model coupling has been shown for biogeochemical models, for integrated nutrient transport and turnover modeling, where CMF acts as a lateral distributor, and the biogeochemical model calculates the reactive flux. In another study, a regional, steady state groundwater flux model has been incorporated as a lower boundary condition of a fully distributed model of inter- and subsurface water flow. CMF is free software; the source code is available for download at http://www.uni-giessen.de/cms/fbz/fb09/institute/ilr/ilr-frede/download