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The CAOS model: a physically based, flexible hydrological model for the mesoscale

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Hydrological models are not only tools to predict discharge, but they are also hypotheses of how a catchment functions with respect to rainfall-runoff behaviour. In this work in progress, we present a new (physically based) model concept that should ultimately be suitable to run at the mesoscale.

To be able to run it efficiently on the mesoscale, the model cannot be too complex. Yet, we wanted it physically based, with explicit incorporation of dissipative structures, such as macropores and lateral preferential flow paths. Besides water fluxes it should also be able to simulate solute concentrations and energy fluxes. This helps to parameterize the model while the model is also thermodynamically consistent, meaning that it is suitable to test thermodynamic optimality principles (such as maximum entropy production principle).

With these constraints in mind, we developed a model where, in each subroutine, flow is modelled in only one dimension (vertical for the unsaturated zone and lateral for subsurface storm flow, groundwater flow and stream flow routines, making the model multiple 1-D), decreasing computation time significantly. The code is developed in an object oriented way, leading to more flexibility to test different model structures. For example, we will demonstrate the effect on simulated rapid subsurface flow for different mathematical descriptions (i.e. the Darcy-Weisbach equation vs. the diffusive wave and kinematic wave equation). For this study, the model will also be evaluated for hillslopes in three different geological settings within the Attert Basin in Luxembourg.