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Darcy multi-domain approach for integrated surface/subsurface hydrologic models

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A Darcy multi-domain approach for modeling surface and subsurface hydrologic processes and their interactions is presented. Two physical domains are considered: land surface and soil. The diffusive wave approximation is used to model runoff. The resulting equation is formulated as a Darcy nonlinear one. Therefore, the water dynamics, including infiltration, flows in both saturated and unsaturated zones and overland flow, is described using a single non-linear Darcy equation with domain dependent parameters. Through a tensorial permeability function in the surface domain, this approach provides a strong coupling between surface and subsurface. The resolution of an advective-dispersive equation is also implemented to be able to determine the origin of water and deal with hydrograph separation and tracer experiments. These equations are solved with a Mixed Hybrid Finite Element formulation. The time discretisation is implicit and the nonlinear equations are solved within a sequential iterative Picard scheme. This model can simulate both Hortonian runoff and overland flow. Different 2D and 3D test cases are presented to show that our model is able to model saturated area spreading and different runoff generation processes. A test case with transport is also presented to illustrate that we can determine the relative importance of "old" and "new" waters in a storm hydrograph and their relative contributions.