HOLISTIC SIMULATION OF FLOW AND CONTAMINANT TRANSPORT IN INTEGRATED SURFACE-SUBSURFACE FLOW SYSTEMS AT THE CATCHMENT SCALE

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ABSTRACT
Over the past several years, increasing attention is being directed towards understanding flow and solute transport processes occurring at the interface between surface water and groundwater, and a variety of numerical strategies have been proposed to couple these processes in a holistic, physically-based modelling framework. In this paper, we will examine these coupling strategies in the context of the *HydroSphere* model, a new generation model for simulating water and solute cycling at the catchment scale. *HydroSphere* is a fully-coupled 3D control-volume finite element model which can simulate water flow and advective-dispersive solute transport on the 2D land surface and in the 3D subsurface under variably-saturated conditions. Full coupling of the surface and subsurface flow regimes is accomplished by simultaneously solving one system of non-linear discrete equations describing flow and transport in both flow regimes, as well as the water and solute fluxes between continua. The results of high-resolution 3D numerical experiments performed with *HydroSphere* are presented which examine the impact of an upland surficial contaminant source on water quality in a nearby stream. The total mass loading to the stream computed with *HydroSphere* includes the down-slope overland flow component during individual rainfall events as well as the portion arising from the discharge of the subsurface contaminant plume into the stream. The catchment under study is about 17 km^2 in area, has about 60 m of topographic relief as defined by a 25m-scale DEM, and is highly heterogeneous in terms of its land use, near-surface soil types and Quaternary geology. Results show that predicted water and solute exchange fluxes across the streambed can vary rapidly in space and time due to individual rainfall events and that short duration, high intensity peaks are not captured if monthly or annual average rainfall is used as input.

RÉSUMÉ