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A catchment-scale groundwater model including sewer pipe leakage in an urban system

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Wastewater leakage from subsurface sewer pipe defects leads to contamination of the surrounding soil and groundwater (Ellis, 2002; Wolf et al., 2004). Leakage rates at pipe defects have to be known in order to quantify contaminant input. Due to inaccessibility of subsurface pipe defects, direct (in-situ) measurements of leakage rates are tedious and associated with a high degree of uncertainty (Wolf, 2006). Proposed catchment-scale models simplify leakage rates by neglecting unsaturated zone flow or by reducing spatial dimensions (Karpf & Krebs, 2013, Boukhemacha et al., 2015).
In the present study, we present a physically based 3-dimensional numerical model incorporating flow in the pipe network, in the saturated zone and in the unsaturated zone to quantify leakage rates on the catchment scale. The model consists of the pipe network flow model HYSTEM-EXTAN (itwh, 2002), which is coupled to the subsurface flow model OpenGeoSys (Kolditz et al., 2012). We also present the newly developed coupling scheme between the two flow models. Leakage functions specific to a pipe defect are derived from simulations of pipe leakage using spatially refined grids around pipe defects. In order to minimize computational effort, these leakage functions are built into the presented numerical model using unrefined grids around pipe defects. The resulting coupled model is capable of efficiently simulating spatially distributed pipe leakage coupled with subsurficial water flow in a 3-dimensional environment.

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