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Understanding solute transport at catchment scales by using a synthesis of bottom-up and top-down modelling approaches

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The understanding of flow paths and travel times of water and solutes in catchments can be substantially improved by a combination of bottom-up and top-down modelling approaches. This hypothesis was tested for the 180 km^2 Ammer catchment in south-western Germany in which the landuse is dominated by agricultural and urban areas. The Ammer River with a mean discharge of 1 m^3/s is mainly fed by springs from karstified and fractured aquifers. A limestone aquifer is extensively used for groundwater production. As a first step, we analysed measured concentrations of major ions, selected organic micro-pollutants and environmental tracers for surface water, springs and deep groundwater from wells using typical top-down approaches such as principal component analysis and lumped parameter models. From these approaches, we gained an initial understanding of water and solute fluxes in the catchment. The initial hypotheses on subsurface flow paths and travel times were subsequently tested using a numerical, 3-D groundwater model as a typical bottom-up approach. Our synthesis of top-down and bottom-up approaches provided us with a reliable picture of the dominant processes governing water and solute fluxes in the Ammer catchment. Several spring waters indicated mixing with wastewater. These contaminations were indentified to be caused by either recharge of surface water or leaky sewer systems. Deep percolation below the plant root zone polluted with agrochemicals was found to affect most springs and surface waters resulting in nitrate concentrations of approximately 30 mg/l. This process also influenced some of the drinking-water wells, although water quality for most of these wells is still relatively high due to some attenuation of pollutants but - above all - due to a significant proportion of groundwater with ages > 50 years. However, water quality will likely decrease if contaminants break through and/or conditions for microbiological attenuation process will deteriorate, for example due to depletion of suitable electron donors.