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Interests and shortcomings of atmospheric tracers (CFCs, SF6) and spectrum of stream tracer concentrations for validation of shallow groundwater catchment transport model

Jerome MOLENAT (1,2), Chantal GASCUEL-ODOUX (2), and Luc AQUILINA (3)

(1) IRD, Laboratoire d'étude des Interactions Sol Agrosystème Hydrosystème, Tunis, Tunisia (jerome.molenat@supagro.inra.fr), (2) INRA, Sol Agro et Hydrosystème et Spatialisation, UMR INRA-Agrocampus Ouest, FR CAREN, Rennes, France, (3) Université de Rennes 1, Geosciences Rennes, UMR CNRS-Université de Rennes 1, FR CAREN, Rennes France

Catchment transit time, i.e. the time it takes for solute inert tracer to move from the soil surface to the stream, can be many year long and distributed over a wide range of values, even in headwater catchments. Quantifying the transit time distribution (TTD) in catchment is crucial from an operational and scientific points of view. Yet it remains a challenging issue. One approach to quantify TTD is to use numerical transport modelling. In this study, we investigate the interests and shortcomings of atmospheric tracers (CFC11, CFC12, CFC113 and SF6) and spectrum of time series of stream tracer concentrations for the validation of transport model in shallow groundwater catchment. The analysis was restricted to base flow transit time (transport by surface runoff and unsaturated flow was not taken into consideration). The application case is the Kervidy-Naizin catchment, a 5 km^2 catchment in Western France, belonging to the Environmental Research Observatory AgrHyS (see http://www.rennes.inra.fr/oreagrhys/).

A two-dimensional groundwater numerical transport model was build from validated groundwater flow model. Three simulations with three different effective porosity values, respectively, were performed. These three simulations have led to mean transit times of 11.8, 2.5 and 1.2 years, respectively. Every transport simulation was then used to simulate mixing ratios for CFCs and SF6 at different locations in the groundwater, in one hand, and to calculate the spectrum of stream tarcer concentration. Meanwhile, spectrum of stream chloride concentrations observed in Kervidy-Naizin stream was also calculated. Analysis of interests and shortcomings of atmospheric tracers and spectrum of stream tracer concentrations was performed based on comparison of observed and simulated spectra, as well as on the comparison of simulated mixing ratios between the three simulations. It turns out that simulated mixing ratios of CFCs are not very different between the three simulations whatever the location in GW. Therefore CFCs tracers appear not to be helpful data for model validation. By contrast, SF6 and spectrum of stream tracer concentrations would allow to discriminate between the three simulations and could be used as helpful tool for transport model validation.