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Comparison of three approaches to estimate residence and transit times in headwater catchments (Environmental Research Observatory AgrHyS, France)

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Residence and transit times are variables of great interest in studying hydrology of headwater catchments. These variables reflect water flow paths as well as hydrologic processes occurring in the catchment. Three approaches to estimate residence and transit times in headwater catchments are presented and compared. The three approaches are i) the spectral analysis of natural tracer concentration times series (Molénat et al., 1999), ii) the numerical modelling (Molénat et al., 2002; Martin et al., 2006) and iii) the groundwater dating with the CFC atmospheric gases (Ayraud et al., submitted). The spectral analysis consists in identifying the transfer function from the cross-analysis of time series of natural tracer concentrations in soil water drainage (or rainfall) in one hand, and in stream water in the other hand. The transfer function can be considered as the transit time distribution of the tracer. In spectral domain, the "actual" transfer function can be estimated directly from the observations and, then, compared to theoretical ones. The spectral analysis requires time series two to three times longer than the mean transit time in the catchment. Numerical modelling consists in building an aquifer flow model and in deriving flowpath and velocity from the flow model. Theoretically, numerical modelling allows to estimate transit times as well as residence times within the catchment. It requires a fine characterisation of the aquifer hydraulic properties, as well as of boundary conditions. The principle of groundwa-

ter age dating with CFCs (chlorofluorocarbons), organic man-made compound, is to calculate the CFC atmospheric mixing ratio from the CFC concentration in groundwater in order to deduce the year the water was for the last time in equilibrium with atmosphere.

The comparison of the three approaches is made based on their applications on the research catchments of the Environmental Research Observatory (ERO) AgrHys. The ERO AgrHyS is composed of small headwater catchments, from 0.1 to 5 km^2, located in Brittany (western France) and equipped for water quality and hydrologic monitoring (http://www.inra.fr/ore_agrhys).

All approaches lead to the same conclusion: the transit time in small headwater catchments can be very long, exceeding one year. However the estimations of catchment residence and transit times are different depending on the approaches. The differences are discussed regarding their hypotheses and their limits.

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