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In defense of tracer cycles for groundwater dating

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The use of tracer cycles to estimate the parameters of a transit time distribution function has been recently criticised by Kirchner (HESSD, 2015). The author shows that the mean residence time of heterogeneous catchments calculated from the damping of the amplitude of the input signal are very often over-estimates, sometimes by large factors. Since all catchments are to some degree heterogeneous, this result seem to spell the end of the method altogether for groundwater dating purposes. In this contribution we want to show that there still might be room for differentiation, and wish to add the following elements to the excellent work of our colleague.
Firstly, the magnitude of the over-estimation depends on the degree of heterogeneity, and is in some cases small enough compared to other sources of error. To show this, we extend the methodology of Kirchner by fitting a lumped-parameter model directly to the transit time distribution (TTD) obtained from the sum of sub-catchments' TTDs.
Secondly, since most groundwater dating methods assume a homogeneous medium, tracer cycles can still be used as secondary data for testing the hypothesis "the degree of heterogeneity of the subsurface is small enough to warrant approximating it by a homogeneous medium". We illustrate this second point with a case-study in a sandstone aquifer drained by contact springs.
Lastly, we introduce temperature as an alternative tracer for groundwater dating purposes, and show that although it is not conservative, its large seasonal amplitude and smooth annual cycle are advantageous compared to stable isotopes and allow to extend the groundwater dating window to about ten years.