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Retrieving the transit time distribution of heterogeneous catchments: theoretical exploration and practical implementation

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Since the seminal work of Maloszewski and Zuber (1982), lumped parameter models have been used widely to estimate the transit time of solutes through catchments using environmental isotopes.
Recently, two problems of the method have begun to be recognised.
The first is the so called truncation problem (Stewart et al., 2010), whereby the mean transit time estimated using the amplitude damping of stable isotopes is much shorter than estimates obtained from tritium data.
The second is the effect of heterogeneities on the shape of the transit time distribution. As shown by Kirchner (2016), mean transit times calculated from the amplitude damping of seasonal tracer signals most likely underestimate the true mean transit times by "large factors". In this contribution, we will show that these two problems are closely related and will explore the following questions:
-can current lumped parameter models assuming homogeneity be combined in such as way as to approximate sufficiently closely the true transit time distribution of heterogeneous systems ?
-which amount of tracer information is necessary to parameterise such models robustly enough to retrieve a close estimate, not only of the mean transit time, but of the entire transit time distribution ?
As we will show, different model combinations yield close estimates of the true transit time distribution up to a very large degree of heterogeneity, especially if stable isotopes and tritium are combined in a single inverse parameter estimation procedure.

References

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