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Residence-timers approach to identify subdomain residence times in composite media like river corridors.

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River corridor beds are often comprised of distinguishable subdomains such as the benthic biolayer and the underlying hyporheic zone. Mixing between streamwater and groundwater, that controls reaction extent for a variety of biogeochemical transformations, can occur at dramatically different rates in the different domains including the stream, the benthic layer, the hyporheic zone, or any combination thereof, depending on the characteristics of the river corridor. For instance the time spent in the benthic biolayer by solutes that start in the stream appears to be an excellent proxy for extent of redox reactions controlling transformation of such solutes. Similary, precipitation/ dissolution reactions may occur predominantly in the lower hyporheic sediment layer(s). Thus it would be useful to have a practical means to determine the residence-time distributions of solutes in any of the subdomains (or a combination) for a given river corridor given their starting place. Such a method could be used in gaining an understanding of the extent of transformation of riverine and/or groundwater solutes, given basic properties of the river corridor such as layer thicknesses, porosities, and diffusion coefficients. To develop such a method we expand upon a notion that the steady-state solution to a multi-domain transient mass balance equation system, that has been fitted with 'residence-timers' (mathematical clocks) for each subdomain, can give the residence time distribution in the separate subdomains or combinations thereof. We present an overview of how this works and demonstrate the results for an example system. The solutions obtained are closed-form in Laplace space, and numerical computation only enters in the final step of inverting the expressions obtained to convert from Laplace space to residence time.

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References

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