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Hydrology and
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Discussions

Interactive comment on "Transport at basin scales: 1. Theoretical framework" *by* A. Rinaldo et al.

Anonymous Referee #2

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General comments

This work proposes a theoretical framework for modeling runoff generation and solute transport at the catchment scale. First the authors discuss the linkage between travel time and lifetime distributions and provide a general theory for simulating flowrates and mass fluxes. The theory is founded on the hypothesis that the underlying transport and mass exchange processes are both linear. Furthermore, mass exchange within the source (hillslope) states is described by a linear sorption reaction under the well mixed hypothesis, i.e. mass exchange between mobile and immobile phases is controlled by the contact time only, and by a gain/loss function within the remaining reactive states. In practice the catchment is subdivided into homogeneous geomorphic states, i.e. hillslopes and channels arranged in a dendritic structure (river network) connecting each hillslope to the outlet, which allows flexibility in considering different source states

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- corresponding, for example, to different land uses - and in connecting reactive with non-reactive states of the river network. The argument treated is relevant and the modeling approach envisioned in the manuscript is a valuable contribution to hydrological sciences. I therefore suggest publication in HESS.

Specific comments

Decoupling of the reaction component, epitomized by m_s, and the transport process, described by the travel time approach, is central to the proposed theory, and justifies the structure of equation (16). The conditions under which this hypothesis is valid are discussed briefly on page 1619 starting from line 10. While, I understand that a large injection area is needed in order to obtain an operational ergodicity which allows confounding solute flux through a control plane with its expected value, such that (16) applies in a single realization, I do not see any need of assuming the further restriction that "the temporal scales relevant for the undergoing advective processes are larger than the characteristic times for the reaction processes". This is indeed the condition under which local chemical equilibrium occurs such that equation (12) resembles the linear equilibrium assumption (LEA): $N(\tau, t_0) = k_D \; C(\tau, t_0)$. Since the manuscript deals with the linear kinetic reaction (12), which does not entail restrictions on the characteristic reaction time, I wonder why the authors introduce it. Furthermore, in the second manuscript of this series the authors show clearly that LEA cannot be applied for simulating nitrate leaching from agricultural areas (see Figure 9 of the second manuscript), and that the characteristic time of advection (see Table 2 of the second manuscript) is smaller than that of reaction (see table 3 of the second manuscript). Therefore, I think that the above restriction on the characteristic reaction time is not needed.

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Technical corrections

- The notation used for the particle trajectory is often inconsistent through the manuscript. Both $\mathbf{X}(t)$ and $\mathbf{X}(t; \mathbf{x}_0, t_0)$ are used and this may confuse the reader. This happens for example on page 1616, line 8, where both notations are used in the same equation.
- I suggest that on page 1616, line 12, $c_w(\mathbf{x}, t; \mathbf{x}_0, t_0)$ is replaced with $c_w(\mathbf{x}, t)$ because c_w is an Eulerian quantity.
- page 1633, line 13, I read: "Notice the difference in the timescale with respect to the travel time $f(t)$ shown in Fig. 2 due to the chromatographic effect... ": I do not see the chromatographic effect invoked by the authors. $f(t)$ and flux concentration peak both around $t = 5\ h$ and show a similar tailing, such that the timescales of the two responses are roughly the same.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 1613, 2005.