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Interactive Comment

Interactive comment on "What can flux tracking teach us about water age distributions and their temporal dynamics?" *by* M. Hrachowitz et al.

Anonymous Referee #3

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This paper nicely and innovatively combines runoff and chloride transport modeling in three Scottish catchments to infer information on travel time dynamics of water inside these catchments. The paper describes the entire process of fitting hydrological and tracer models to 3 catchments. A major innovation is the evaluation of multiple mixing concepts and their effects on travel times of water. Additionally, the introduction gives a very complete overview of the state of the art in conceptual hydrologic and transit time modeling, which is a big achievement given the large number of papers that haven been written on catchment travel times during the past years. The largest problem of this paper is its length. The paper could probably have been subdivided into 2 or 3 papers. Possible ways to shorten the paper would be to focus on the travel time distributions and skip the 4 wetting regimes, the long power tails and the travel time distributions of chloride. This would shorten section 4 considerably . However, it is up to the authors and I will not further object to the length of the current manuscript. Below I listed several major and minor comments, but nothing really major, and I recommend this paper for publication after minor revisions.

Major comments:

Eq. 34: Here you add discharge and evapotranspiration distributions which give the overall distribution. I don't think this is correct: adding 2 distributions never yields another distribution. As I understand it, in Eq 34 pTQ(ti,tj-ti) and pTE(ti,tj-ti) are partial distributions as they do not sum up to 1. In my opinion you have to weigh the distributions with the fluxes similarly to eq. 35. This weighing factor determines how much of the rainfall goes to discharge or to evapotranspiration: Ptot(ti,tj-ti)=RQ(ti)/Rtot(ti)*pTQ(ti,tj-ti)+RE(ti)/Rtot(ti)*PTE(ti,tj-ti) In which Rtot(ti) in the total amount of precip at ti, RQ(ti)/Rtot(ti) is the fraction of Rtot that ends up as discharge Q, RE(ti)/Rtot(ti) the fraction of of Rtot that ends up as evapotranspiration, E. With this definition pTQ(ti,tj-ti) and PTE(ti,tj-ti) are real distributions and Eq. 34 and 35 follow similar reasoning/patterns. This problem is further reflected in Fig.11 where it is clear that the different traveltime "distributions" do not sum up to 1. If they do not sum up to 1, they are not distributions!!. To me this is very confusing. The same happens in Figures 6,8 and 12. Here I do not understand why many of the distributions do not sum up to 1. They should if you refer to them as age distributions, as you say in the figure subscript. Somewhere you state that you only look at 5 years, but the cumulative distributions do not indicate 100% will be reached in the future. Please correct this.

In section 3 I cannot find how chloride transport with transpiration is conceptualized. From section 4.6 I think to understand that chloride is not taken up by plants while water is(transpiration). Im curious how you can justify this assumption. You have relatively low chloride concentrations in the groundwater and plants need chloride. I do not think that plants will put in the large effort to completely separate chloride from the water. Instead it is much more likely that plants take up this chloride (look in literature for chloride concentration in vegetation). In your system chloride is then cycled via mineralization of organic matter. This of course yields much longer transit times for chloride than you have now calculated. The delay caused by the plantuptake and mineralization is substantial (likely to years) and could also explain part of the large delays now entirely attributed to mixing with deep storage (Ss/Sp, overestimation of your storage).

Section 4.3 I can't work out what we are exactly looking at in figs 6,7„8,11. You model an age distribution for every time step (Fig 9). Therefore I guess that in fig 6 Im looking at some sort of average distribution. I wonder if it is a time averaged distribution or a flux averaged distribution. This makes a huge difference. More info is needed. And clarify why you look at a time averaged distribution in stead of a flux averaged one.

Minor comments:

Page 11368,line 25 a summary of

Page 11371, line7, manure and fertilizer input are major sources of cl, just as road de-icing.

Page 11371 line27: This more of a general comment on the flexible model structure approach: You say you use the information available, but there is so much more information that you do not use in this model approach. For example topography, soil maps, geological maps, vegetation cover etc... I'm sure that these sources of information could constrain your models. For example I'm curious if the fitted storage volumes on discharge and chloride loads are possible if you consider the amount of pore space in your catchments. In the end the amount and dynamics of storage largely controls your travel times/chloride dynamics.

Page 11377, line 5, I -> italic(I)

Page 11378 (Eqs 25-26) -> Eqs 26,27 ?

Section 3.3: I think this section would improve if there was a conceptual figure that

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explains the different mixing schemes, and how they are parameterized. How mixing is parameterized is one of the innovations of this paper but it is very hard to understand from these sections. I think you built it up nicely: First complete mixing, then adding parameters Sp and CM for incomplete mixing, than sumax, μcm and σcm for partial mixing Section 3.3 How do the lag functions in the hydrological model influence the travel time distributions? If you introduce lag functions you modify the storage in the system. Is this accounted for?

Page 11381, line 20 rephrase "be on the one hand be"

Page 11391, line 5 "a break in at"

Page 11392, line 11 Hence, although

Page 11398: what new information can be obtained from pT that could not be derived from pF discussed earlier?

Page 11398: line 19: Here you mention 5 years. Are these "distributions" determined over only 5 years? The shape of the cumulative distributions does not indicate that 100% will ever be reached. why not? I do not understand why only 65% of the water entering during dry periods has left this catchment after 5years.

Page 11400 I think plant uptake of chloride cannot be ignored. Ignoring plant uptake leads to an overestimation of your groundwater storage Ss/Sp, in order to buffer modeled seasonality in chloride concentrations.

Figs 6,7,8, 11 why stop the cumulative distribution at 1000 days? Why not continue to 10000 days as several of the distributions did not yet reach their maximum: 6.11 and 6.12

Page 11435, Fig 12 What do you mean with a solid solute?

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 11363, 2012.