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Hydrology and Earth System Sciences Discussions

Interactive comment on "On the use of spring baseflow recession for a more accurate parameterization of aquifer transit time distribution functions" *by* J. Farlin and P. Maloszewski

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Dear reviewers, dear editor, The manuscript has been reworked to improve clarity, especially in the mathematical formulations and in the site description of the case study. We thank you for all your comments and remarks. Please find below our response to specific comments.

Referee #1

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Interactive Discussion

Discussion Paper

1. The introduction to paragraph 2 was completely removed, including the sentence which Referee #1 had suggested modifications to.

2. For such a simple problem, it is probably irrelevant which method is used to find the minima of the error function. It is however useful to compute this function explicitly with η as variable, since the comparison between η values predicted by tritium alone or in combination with the spring baseflow recession can then be done visually as well. The authors used an R code to compute the function and find the minimum, but PEST would surely do just as well.

3. The paragraph has been modified to introduce the concept of mobile and immobile water zones. The description of fracture and matrix porosities in the paragraph detailing the study area has been modified accordingly.

4. The uncertainty interval is calculated from the uncertainties in the proportion of cropland found in the catchment. This is now explained more fully in paragraph 3.2. The relationship between the transfer functions for atrazine and tritium and cropland is also slightly elaborated upon in paragraph 2.1.

5. The term influenced was indeed insufficiently clear. We have replaced all mention to "influenced" discharge by explicit references to recharge taking place during the recession period.

Referee #2

10,24: The sentence was modified.

12,9: See Referee #1 comment 1.

12,16: See Referee #1 comment 1.

12,23: "Transit time" is now used throughout the text.

13,3-4: We tried to be careful in our wording by emphasizing that the residence times in the unsaturated zones are "approximately" equal. We do agree that the vertical tran-

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sit time of all flow lines cannot be absolutely the same, however: 1. In the absence any data concerning the heterogeneity of the fracture network and its influence on the hydraulic conductivity, this is the only workable hypothesis (similar to setting a unique value for the vertical hydraulic conductivity of the entire model region or sub-region in a numerical groundwater model). 2. It is reasonable to expect that vertical velocities through a densely fractured, transmissive 40 and more meters thick sandstone formation will not differ by more than an order of magnitude (on the contrary to the exponentially-distributed residence times in the saturated zone).

13,14: The functional relationship between both transfer function, and especially the role of the proportion of cropland present in the catchment, is now explained more fully in paragraph 2.1. We still wish to refrain from reprinting the mathematical derivation, since it can already be found in Farlin et al. (2013) and is not the main focus of this manuscript, which we prefer to keep compact and to the point.

13,20: The paragraph was modified and the unclear definitions streamlined. See also Referee #1, comment 3. We agree with Referee #2 that a figure might help the reader understand the difference between dynamic and minimal volumes, but still hope to that the written explanation is now sufficient. Interested readers can read Zuber (1986) for details.

14,9: Parameter estimation was performed by computing the error function defined by equation (4) and finding the global minimum in function of η. Visual verification was meant both for the predicted vs. observed tritium data and the shape of the error function. For such a simple case, plotting the error curve seems absolutely sufficient. See also Referee #1, comment 2.

15,12: There may indeed by other reasons for stagnant water to be present in the aquifer, however: 1. The hydrogeological system under study is quite simple (especially the boundary conditions). The unconfined aquifer sits like a slab on a subhorizontal aquiclude and is being drained by numerous springs emerging all around

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it. 2. There is no data concerning extreme heterogeneities within the sandstone formation, and no reasons to suspect their existence. That is why we adopt the simplest model of a homogeneous aquifer, which we then test. Since this simple model passes the test we have devised, we keep it until better data becomes available.

15,18: We agree, and modified the paragraph considerably. See Referee #1, comment 3.

16,12: The section was augmented to provide more information on the climatological and hydrogeological setting. The estimated mean groundwater residence times were moved to paragraph 3.2. We believe that there is no need to further separate previous results from the description of the site. Our aim was to summarize compactly in one paragraph all that is known about the site and relevant to the present study, and point out in what way the study sheds new light on some previously unresolved questions. This is also why we did not mention which method was used to measure atrazine in groundwater. A reference to Farlin et al. (2013) was added for the interested reader.

16,17: The average thickness of the unsaturated zone is now given in paragraph 2.3. See also previous comment by Referee #2 (13,3-4).

16,25: The description of the sampling scheme was modified, and the number of springs sampled is now given as well.

18,3: See Referee #1 comment 5.

18,18: A new paragraph was added to the method section (paragraph 2.3) and all explanations concerning atrazine's application history and time series fitting was moved there.

19,12: The paragraph was restructured to make clear that the reconstructed atrazine input, which retro-predicts that the end of the leaching phase corresponding to the decrease in spring concentrations observed in 2011 happened in 1996, agrees with the change in application practice that took place during that period.

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19,13: The phrasing was changed.

20,1: The entire paragraph was extended and clarified. As for the assumption of a uniform unsaturated zone, see response 13,3-4 and 15,12 above.

20,4: Since the boundary conditions of the sandstone cuesta is simple (no groundwater inflow from a regional flow system, no surface water infiltration), the only variable is the net recharge, which is unknown. Quantifying the dynamics of that recharge at, for instance, monthly time steps would require setting up a bucket model such as mentioned in the discussion (or even a more complex physically-based one). We believe that since one of the tritium models agrees well with the recession model, there is no need to introduce additional complexity to the analysis (a sentence on that matter was added to the discussion).

Comment by Mr. John Ding

The intermediate steps leading to equation (6.2) are now given. Note that the equation given by Mr. Ding reduces to equation (6.2) at the limit lim t->t0=0.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 14109, 2012.