General comments of Referee #1

In this manuscript, the authors present a transient storage model they developed. This model is similar to some existing ones (OTIS mainly) and the aim of the authors is to show the advantages of their model. I think that the research developed in this manuscript could be worth publishing but that the demonstration made through the manuscript is not really convincing. I would recommend a major revision of this manuscript for the following reasons:

- The manuscript need to be rewritten in correct English. I would advise the writers to ask the help of an English speaking reviewer.

- The last part of you manuscript (section 4) implying the real case studies is not clear. You compare the simulations made by your model, OTIS and Mike11 to the real data. However your simulations are based on a set of fixed parameters but we don't know where these come from… Have they been calibrated by another program? In this case which one? Why would these parameters be considered as the right ones? My point is that maybe you would have a better fitting to the real data with another program in considering another calibration….! Actually, what you should compare is the best fit you can have for each model in calibrating the parameters for each model. So you'll have 3 different sets of calibrated parameters and that would be interesting to see if they are close or very different.

- OTIS is often really close to your model result. I'm not really convinced that getting slightly better statistical analysis is enough to show the efficiency of a model. The real point of developing such models is their use to dimension the geometrical and transport parameters in rivers. I think that showing the numerical and statistical stability of you model is not enough and that you should show the impact of your model on the parameterization.

Answer to General comments of Referee #1

Thank you for allocating your time to review our manuscript. You have mentioned valuable points, we really appreciate.

-English language will be improved in the revised version, definitely.

-It is necessary to mention a few points in response to the above comments:

- In section 4, we aimed to compare three different models with some features have in common, so we should use a set of fixed parameters.
- These parameters have physical interpretation, hence they must have one quantity in the real word.
- Some researchers obtain the values of these parameters from tracer study data, the parameters we employed in our study, (such as Bencala and Walters (1983), Bencala (1983) and Runkel et al. (1998)). Bencala and Walters (1983) show the application of transient storage model to field data by using of Chloride injection experiment data that conducted at Uvas Creek,

California. They select the model parameters by visually determining the set of parameters which yielded the 'best fit' to the observed concentration data (a trial-error process). Bencala (1983), also estimate the simulation parameters based on a trial and error simulation to get the best fit between simulated and observed data. Runkel et al. (1998) used a solute transport model to simulate the downstream transport of Li as a conservative tracer under unsteady flow condition. They estimated Transient storage parameters for each stream reach by comparing the observed Li data with the model simulations. They did that by using nonlinear least squares method.

- Due to the above comments, we rechecked the models by increasing and decreasing the parameters by the same magnitude and concluded that all model show less difference between the real and calculated data, so we can say that those parameters are also roughly calibrated for this study.

For more details please see:

- AVANZINO, R. J., ZELLWEGER, G. W., KENNEDY, V. C., ZAND, S. M. & BENCALA, K. E. 1984. Results of a solute transport experiment at Uvas Creek, September 1972. USGS Open-File Report 84-236 1984. 82 p, 40 fig, 9 tab, 5 ref.

- BENCALA, K. E. and WALTERS, R. A. 1983. Simulation of Solute Transport in a Mountain Pool-and-Riffle Stream: A Transient Storage Model. Water Resources Research, 19, 718-724, doi:10.1029/WR019i003p00718.

- BENCALA, K. E. 1983. Simulation of solute transport in a mountain pool-and-riffle stream with a kinetic mass transfer model for sorption. Water Resources Research, 19, 732-738, doi: 10.1029/WR019i003p00732.

- Runkel, R. L., Mcknigh, D. M. and Andrews, E. D. 1998. Analysis of transient storage subject to unsteady flow: diel flow variation in an Antarctic stream. Journal of the North American Benthological Society, 143-154.

-Yes, you are right, for the cases that run in this study, the results of OTIS model is almost near to our model results. Because most of the given examples are dispersion-dominant transport ones, while as mentioned frequently in the paper, our model has better performance in advection-dominant cases, where the flow velocity is relatively high. It is also interesting to point that transient storage often observed in mountain rivers and streams, where the flow velocity is high due to high slopes and as a result advection is dominant process of solute transport. However, using of these examples were inevitable due to unviability of more observed data and we tried to show our model superiority with available data, as much as possible. Also, it should be mentioned that, OTIS use central differencing scheme in spatial discretization of transport equations which has second-order accuracy whereas we used from QUICK scheme (a third-order numerical scheme). QUICK capabilities discussed a lot in numerical text books. Also, presented model has the ability to simulate solute transport problem in both with and without transient storage conditions under steady or unsteady flow regimes, in rivers with irregular cross-section (without limitation in sections number). We have a few numerical models that can handle solute transport with transient storage in complex and different conditions, so we believe that there is a requirement to models such as our model.

Specific comments of Referee #1

1-Page 3, line 16. What defines a "good performance"?

Answer:

"Good performance" for every numerical method, can be interpreted as convergent and accurate results without numerical oscillations. It is known that, the central differencing method, which has been widely used for solving solute transport equations, in certain applications such as advection-dominated transport, can lead to artificial oscillations in the form of overshoots and undershoots. This point can be investigated by solving the transport equations using a small dispersion coefficient, almost near to zero (similar to what we did in sec 4.1. example 1). Figure 8 page 13, shows that the simulation results obtained by CTCS scheme have very large oscillations. However this oscillations can be minimized by the use of finer grid, with the choice of Δx based on the dimensionless Peclet number, but the associated computational cost due to excessively fine grid may become impractical in many of applications. However the additional explanations will be given in revised version.

2- Page 6, line 20. The parameters involved in the DaI and their units should be mentioned.
Furthermore, in addition to the DaI, I would also consider the numerical Peclet and Current to asses of the model stability for each simulation.

Answer:

-The involved parameters in DaI and their units will be added to the revised version.

- DaI is a dimensionless number that reflects the exchange rate between main channel and storage zone, not a criteria for assessment of model stability. When DaI is much greater than unity, for example 100, the exchange between main channel and storage zone is too fast that could be assumed that these two segments are in balance. When DaI is much lower than unity, for example 0.001, the exchange rate between main channel and storage zone is very low and negligible. In the other words, in such a stream where DaI is very low, practically there is no significant exchange between main channel and storage zone and transient storage does not affect downstream solute transport. It usually said that when DaI value is between 0.1 to 10, transient storage is involved in downstream transport.

For more information please see:

-Ramaswami, A., Milford, J. B., and Small, M. J.: Integrated Environmental Modeling: Pollutant Transport, Fate, and Risk in the Environment, J. Wiley, Hoboken, New Jersey, 2005.
- Jin, L., Siegel, D. I., Lautz, L. K., and Otz, M. H.: Transient storage and downstream solute transport 5 in nested stream reaches a_ected by beaver dams, Hydrol. Process., 23, 2438–2449, 2009
- Scott, D. T., Gooseff, M. N., Bencala, K. E., and Runkel, R. L.: Automated calibration of a stream solute transport model: implications for interpretation of biogeochemical parameters, J. N. Am. Benthol. Soc., 22, 492–510, 2003.
-Fernald, A. G., Wigington, P., and Landers, D. H.: Transient storage and hyporheic flow along the Willamette River, Oregon: field measurements and model estimates, Water Resour. Res., 37, 1681–1694, 2001.
- Harvey, J. W. and Wagner, B. J.: Quantifying hydrologic interactions between streams and their subsurface hyporheic zones, in: Streams and Ground Waters, edited by: Jones, J. A. and Mulholland, P. J., Academic Press, San Diego, USA, 3–44, 2000.
-Wagner, B. J. and Harvey, J. W.: Experimental design for estimating parameters of rate-limited mass transfer: analysis of stream tracer studies, Water Resour. Res., 33, 1731–1741, 1997.

-The Peclet and Courant numbers will be considered in the revised version.

3- Page 7, line 24. The meaning of the error indexes you calculate must be roughly explained.

Answer:

In this manuscript we use from four error indices for assessing the accuracy of models.

The square of the correlation coefficient (R^2), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), which has the same dimension as observed data, and Mean Relative Error (MRE). A brief explanation about these indices will be given in the revised version.

4- Page 10, section 3.2. The main features of the 2D-model should be explained. Why do you consider it as a reference to which other models must be compared?

Answer:

The transient storage phenomena is occurred due to velocity differences between the main channel and storage zones (areas that assumed to be stagnant relative to main channel). 2D models consider velocity variations in two dimensions of river and so give more accurate predictions of solute transport behavior in reality. Which means that it takes into account the effect of TS zones automatically, and could be used for our model verification as a reference.

5- Page 11, line 13. All along the manuscript you use sometimes “CTQS, CTCS, BTCS” or “This study, OTIS, Mike11”. Please choose one of those nomenclatures to more clarity.

Answer:

It will be done in the revised version.

6- Page 11, line 18. Why is a tiny least error percentage synonymous of better accuracy?

Answer:

The presented model in this study shows its abilities better in the cases where advection is dominant mechanism of transport. We believe that this tiny least error percentage is involved because the example does not very advective, so the results of the proposed models are slightly close. Otherwise our model certainly showing better performance than the other ones.

7- Page 12, figure 7b. How can you simulate a BTCS with storage while you mentioned in Table 1 that Mike11 is not able to simulate transient storage..?

Answer:

For each numerical scheme that studied in this paper, a numerical code has been developed.

This figure has been drawn based on the results that obtained from numerical code of BTCS method for this example. For more clarity, this point will be explained in the revised version.

8- Page 13, line 14-15. I don’t see your point. The example developed in this chapter considers no storage.

Answer:

This is a standard test for assessing of robustness of numerical schemes (Leonard, 1991, Lin and Falconer, 1997, Neumann et al., 2011). This example is designed to show the superiority of numerical method that used in the presented model for pure advection case. It is worth to mention that in mountain rivers and streams, where transient storage mechanism also more observed in such rivers, due to relatively high slope, have higher flow velocities than plain rivers, and as a result, advection is the dominant process in solute transport. Hence, if a numerical method be able to simulate advection dominant cases more accurate than the other ones, it will be more applicable for simulation of solute transport in rivers with transient storage.

References:

-LEONARD, B. 1991. The ULTIMATE conservative difference scheme applied to unsteady one-dimensional advection. *Computer methods in applied mechanics and engineering*, 88**,** 17-74.
- LIN, B. and FALCONER, R. A. 1997. Tidal flow and transport modeling using ULTIMATE QUICKEST scheme. *Journal of Hydraulic Engineering*, 123**,** 303-314.doi: 10.1061/(ASCE)0733-9429(1997)123:4(303)
- NEUMANN, L., ŠIMŮNEK, J. and COOK, F. 2011. Implementation of quadratic upstream interpolation schemes for solute transport into HYDRUS-1D. Environmental Modelling & Software, 26**,** 1298-1308. doi:10.1016/j.envsoft.2011.05.010

9- Page 14, fig. 9 and 10. Those figures are not necessary. They are redundant with figure 8.

Answer:

Figures 9 and 10 will be removed from the revised version.

10- Page 17, table 16. The origin of the parameters calibration should be explained. See the general remark above.

Answer:

These parameters are chosen based on the work that carried out by Bencala and Walters(1983). They show the application of transient storage model to field data by using of chloride injection experiment data that conducted at Uvas Creek, California. They select the model parameters by visually determining the set of parameters which yielded the 'best fit' to the observed concentration data (a trial and error process).

For more information please see:

-BENCALA, K. E. and WALTERS, R. A. 1983. Simulation of Solute Transport in a Mountain Pool-and-Riffle Stream: A Transient Storage Model. Water Resources Research, 19, 718-724,doi:10.1029/WR019i003p00718.

11-Page 19, Figure 16. How were the storage zone concentration simulated?

Answer:

The storage zone concentrations obtained from Equation 3 (for conservative solute) or equation 5 (for non-conservative solute). Actually, the final outputs of presented model are the main channel, storage zone and sorbate concentrations. The last one is obtained from equation 6, for the cases that kinetic sorption is involved in solute transport (non-conservative solute).

12- Page 19, lines 9 to 17. The importance of simulating storage areas in such transport is well known and has been demonstrated by other authors. I don't think your manuscript should include this discussion because it is not the point of your paper.

Answer:

These lines will be removed from the revised version.

13- Page 20, table 18. The origin of the parameters calibration should be explained. See the general remark above.

Answer:

The parameters such as input and background concentrations have taken from the results of Uvas Creek experiment. The values of Distribution and sorption rate coefficients selected based on Bencala (1983). He estimate these parameters based on a trial and error simulation to get the best fit between simulated and observed data.

<u>For more information please see:</u>

- AVANZINO, R. J., ZELLWEGER, G. W., KENNEDY, V. C., ZAND, S. M. & BENCALA, K. E. 1984. Results of a solute transport experiment at Uvas Creek, September 1972. USGS Open-File Report 84-236 1984. 82 p, 40 fig, 9 tab, 5 ref.

- BENCALA, K. E. 1983. Simulation of solute transport in a mountain pool-and-riffle stream with a kinetic mass transfer model for sorption. Water Resources Research, 19, 732-738, doi: 10.1029/WR019i003p00732.

14- Page 22, table 19. At 433 m, all models have rather bad error indexes. How can you explain that? To me, this could be linked to a wrong initial parameters calibration…

Answer:

In order to justify this results it should be said that, the MIKE 11 does not take into account the effect of transient storage and kinetic sorption, so we had expected such results. About two other models, if you exclude the R^2 index, other error indexes does not show significant difference with two other stations.

15- Page 23, lines 19-20. You never mentioned trial error tests before. Where does it come from? Did you do trial-error tests to calibrate transient storage? So you should have three different values of transient storage parameters for each model? This is not clear…

Answer:

We did not made a trial-error test for previous examples, because the parameters had been calibrated before by some researchers. But for this particular example, the calibrated parameters did not exist, hence we perform a trial-error work to determine transient storage parameters.

16- Page 25, table 22. The origin of the parameters calibration should be explained. See the general remark above

Answer:

We used from the parameter estimation that given by Runkel et al. (1998). A tracer study was conducted in January 1992 at Huey creek located in the of McMurdo valleys, Antarctica. Lithium tracer was injected into Huey Creek over a 3.75-hour period. Runkel et al. (1998) used a solute transport model to simulate the downstream transport of Li as a conservative tracer under unsteady flow condition. They estimated Transient storage parameters for each stream reach by comparing the observed Li data with the model simulations. They did that by using nonlinear least squares method.

For more details please see:

-RUNKEL, R. L., MCKNIGHT, D. M. & ANDREWS, E. D. 1998. Analysis of transient storage subject to unsteady flow: diel flow variation in an Antarctic stream. Journal of the North American Benthological Society, 143-154.

17- Page 26, table 23. I'm surprised Mike11 has a much better R^2 than the two others. Are you sure of those values?

Answer:

It should be mentioned that higher R^2 doesn't equivalent to a better performance of model, necessarily. The R^2 index just shows the trend of a set of data. For example if you assume these two set of data: (1, 2, 3, 4, 5) and (1000, 2000, 3000, 4000, 5000), then calculate the R^2 of them, you get R^2=1, while they have large discrepancy (but they have same trend).

18- Page 27, section 5. Why did you performed the sensitivity analysis on the transient storage parameters only? Your model does also dimension dispersion and main flow section. So to me, they should be part of a sensitivity analysis as well.

Answer:

It will be done in the revised version.

19- Page 27, line 18-22. What is the meaning of “not remarkable delay” or “significant increase” in this context? It should be quantified.

Answer:

It will be considered in the revised version.

20- Page 28, fig 24 and 25. The initial model fitting (the “0% change”) must be shown on the graph.

Answer:

It will be done in revised version.

Technical comments of Referee #1

-Page 1, equation 1, line 23-24. Units should be mentioned; either here or in a general notation section.

- Section 2, page 3 to 6. Units should be mentioned; either here or in a general notation section.

- In all your error indexes tables, your data must be presented with the same number of significant digits after the coma in order to be compared accurately.

Answer:

It will be considered in the revised version.