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Hydrology and Earth System Sciences Discussions

Interactive comment on "Quantifying spatial and temporal discharge dynamics of an event in a first order stream, using Distributed Temperature Sensing" *by* M. C. Westhoff et al.

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We would like to thank anonymous referee 2 for his/her close reading and useful comments on the manuscript. Below we answer all questions, immediately after the issue raised.
Reviewer comments are in italic

General comments: This paper shows how a model is used in combination with temperature and streamflow data to deduce the locations of lateral inflow, infiltration,

and hyporheic exchange. The authors lead the reader through their modeling steps. This allows one to see the many steps involved in the process and how models can be used to better understand the study reach/study watershed. However, it is sometimes hard to keep track of the different steps, which parameters are changed and how this influences the objective functions. I therefore suggest that the authors include a table that shows the steps, the parameter values and model performance for each step. It would be useful if the authors would comment more on whether their final model is just a possible model or if this is indeed the best model and especially whether or not this model will be adequate during wetter conditions when inflow from the hillslopes is more likely to occur as well. In the revised manuscript we shall include a table to hold track of all changes in parameters during the different calibration steps.
The model is not presented as the final unique solution, but as a learning tool, used to test hypotheses. In the manuscript we only tested a few hypotheses, based on our knowledge of the field, and on which processes we think may occur. During wetter conditions gains and losses will be different, but the same method can be used to test hypotheses during those conditions (as long as there are enough temperature fluctuations). We shall make this clearer in the revised manuscript.

This stream is characterized by significant inflows and losses (infiltration). The authors mention the locations and relative losses and gains but don't describe how (and when) these losses and gains were determined in the field. Since this is a central part of the model, more information on how these losses and gains were determined needs to be given.
We shall extend the site description, giving more details about the gains and losses found in he stream reach.

More information should also be given on the calibrated model that is used in this study. The reader is referred to a paper that is in review and thus not widely available.

More comparison between the conditions during the calibration period and the period of this study should be given as well.
We shall expand the method section so as to describe the used method in more detail (similar to the description in Westhoff et al., 2011). We shall also give more information about the conditions of the calibrated model (which were similar to the pre-event conditions of the study period of this manuscript).

Finally, it would help if a bit more information about the study reach was given.
We shall add a more detailed site description.

Specific comments: 1. P2177L21: Other studies have used differential streamflow gauging to study lateral inflows and/or streamflow losses (e.g. Anderson and Burt, 1978: The role of topography in controlling throughflow generation; Hjelmfelt and Burwell, 1984: Spatial variability of runoff). Include references to these types of studies as well.
Thank you for these suggestions. We shall include them.

2. P2178L20, P2179L1: Describe what the bypasses are. Are these side-channels or something else? How big are these bypasses?
The bypass is a small side channel of ca 20 m with a similar width of the stream itself. We shall make this clearer in the revised manuscript.

3. P2178L25: Give the total precipitation and the average intensity of the event.
We shall add these numbers

4. P2179L7: Give the average slope of the hillslopes as well.
We shall do that.

5. P2179L15: More information about the stream should be given. How deep is the sediment in the stream? What is the size of these rock clasts or what was the D84? Is this a meandering stream or a stream that is characterized by step-pools and bars or woody debris? How wide is the stream?
More information will be given about the stream and the subsurface.

6. P2179L20: Give more information about the size (or %contribution) of these lateral inflows and how these lateral inflows and losses were determined. These lateral inflows and losses are a major focus of the remainder of the paper but are not described adequately in the site description section. On P2180L1, salt injection tests are mentioned but no information is given about them. On P2181L11-14, it appears that these inflows are based on model calibrations. Expand on how information on inflows and infiltration losses was obtained (and the uncertainty of these measurements).
The 4 major inflows were already identified in earlier studies (Selker et al., 2006a and b; Westhoff et al., 2007) during the first employment of DTS in this stream. During other field visits, the 2 smaller ones were identified as well. For the pre-event conditions we quantified their contributions relative to the discharge just downstream of the inflow with a simple mass balance, knowing the temperature of the inflow as well as the temperature just upstream and downstream of the inflow. In the revised manuscript we shall explain this better.

7. P2180L1: Was there anything special about the locations where the water infiltrates? Show the locations of these infiltration zones on Figure 1.
We could not see anything special about these areas, other than that during even lower flows, these parts dried up. We shall indicate these locations in Fig 1.

8. P2180L2: What was the streamflow during these salt injections? Compare to the flow rates during this study.
We have done these injections several times during similar flow conditions and during flow condition approximately twice as high.

9. P2180L5: Give the scale or size of the small scale exchange - what is small?
Small scale is smaller than 1 grid cell in the numerical solution: i.e. water infiltrates and exfiltrates within the same grid cell, in our case 1 m.

10. P2181L12: Give more information about how good the water-balance was.
The relative contribution of the 4 major inflows where determined with the mass and energy balance, knowing the temperature upstream, downstream and of the inflow itself. The stream losses were such that the water balance was exactly closed (meaning a perfect fit). Note that these were determined during steady state pre-event discharge conditions.

11. P2183L7: How did you determine where hyporheic exchange occurred? This is not described in the methods. Explain.
This is described in Westhoff et al., (2011), which is still under review. We shall therefore expand the methods section where we describe in detail the model, and how the hyporheic exchange has been calibrated.

12. P2183:10: How similar/different was the min, max, and mean streamflow during the calibration period compared to that in this study?
The calibration period was during steady state discharge condition with an upstream discharge of 0.35 l/s and downstream discharge of 0.47 l/s, compared to 0.44 l/s and 0.62 l/s during this study.

13. P2183L20: It is hard to keep track of what parameters are changed during which step and how it affects all of these objective functions. It would help if a table was included that would show the steps, which parameters were changed (and by how much) and how it changed all objective functions (and whether these are for the whole hydrograph or just the first or second peak). Currently, the effect on only one of these objective functions is given in the text.
This is a very good suggestion. We shall add this table in the revised manuscript.

14. P2186L3: This bypass has to be described in more detail. Is this a side channel? Or overland flow over a lower lying section? It is unclear what this bypass flow is or what controls this bypass flow.
As explained in comment 2: The bypass is a small side channel of ca 20 m with a similar width of the stream itself. We shall make this clearer in the revised manuscript.

15. P2186L12: What are the results for the other objective functions/criteria mentioned on P2183?
Both objective functions had a perfect match during pre-event conditions because both were determined directly from observations.

16. P2186L22: How is this value of WR different from that used in the calibrated model?
The calibrated model (as described by Westhoff et al., 2011) was calibrated during steady state discharge conditions during which it did not rain. Therefore we could not calibrate W_R during that study.

17. P2189L19: Based on what data/field information does the value of 1.7m for WR

seem realistic?
The maximum simulated stream width was between 0.22 and 1.47 m. A slightly wider area where the soil is saturated seems realistic, although we already recognize that the value of 1.7 m has limited physical meaning, since it directly corrects for an error in rainfall measurements or peak discharge measurements.

18. P2190L24-29: What is the basis for these stream widths? Are these field measurements during this event or is it deduced from the topography and stage data or from the model? Please describe how this information was obtained.
We obtained detailed observations of cross-sectional areas at 64 locations along the stream using a pin board. With this we could determine the stream width for each depth. The stream depth is a result of the routing model.

19. P2192L8: Give examples of how sufficient additional energy can be added to the stream.
One could think of adding ice, or put a heat exchanger in the stream. We recognize that there may be practical problems involved with this, but we encourage people to come up with a good idea. The method may also be tested downstream of a reservoir. E.g. Toffolon et al., (2010) report temperature changes of 3 to 4 degrees during short releases from a reservoir. In their study, the stream was way larger than the stream in this study (10 m3/s). But it may be worth trying.

20. References: It is unclear why the page numbers where these articles are referenced in this paper are included in the references.
This is the layout of HESSD.

21. Figure 1: Show the locations of infiltration as well.

We shall do that

22. Figure 2 and figure 5: The difference between Qd and Qup is hard to see when the figure is printed in black and white. Use a different color scheme or label the lines in the figure. Combine these figures as they are almost the same?
The reason to split these figures was that otherwise the reader would be confronted at an early stage with model results that are discussed much later. In the revised MS we shall check if it is worthwhile to combine the figures into 1.

All editorial suggestion will be followed up.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 2175, 2011.