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Hydrology and Earth System Sciences Discussions

Interactive comment on "Assessing hyporheic zone dynamics in two alluvial flood plains of the Southern Alps using water temperature and tracers" *by* E. Hoehn and O. A. Cirpka

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Hydrol. Earth Syst. Sci. Discuss., 3, S223-S227, 2006 hessd-2005-0112 Interactive reply to referee's comments, by E. Hoehn O. Cirpka

GENERAL REFEREE'S COMMENTS

Misleading title The referee objected the use of the expression "dynamics" in the title of our work. We have changed the title too: "Assessing residence times of hyporheic ground water in two alluvial flood plains ofthe Southern Alps using water temperature and tracers"

No information about 2nd site, apart from water temperature (P351, lines 1-13; P352,

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lines 17-21) Analysis of the 2nd site relies indeed exclusively to information about temperature, although we state that further information is necessary. We conclude from the uncertainty in the temperature data that further information is required.

Dimensionality of System (P347) The referee criticized the assumptions of uniformity and one-dimensionality. In fact, only the analytical expressions for sinusoidal fluctuations (Eqs. 8-10) are based on these assumptions. We have included the latter expressions because they exemplify under which conditions the observed travel time of temperature fluctuations can exclusively be related to retarded convection. Before restating the transport equations for temperature and concentration, we talk about transport "within a non-interacting stream tube" (p. 5, line 1). This stream tube need not be straight. And the properties may vary along the trajectory. In the analysis of the field data, we do not presume uniformity or one-dimensionality of the system. We are well aware that downwelling flow systems of river water to ground water are by nature non-uniform and three-dimensional. A three-dimensional assessment of the river bed, however, comes with an unacceptably high experimental effort. In a heterogeneous system with limited spatial resolution, switching into the travel-time domain is appropriate because in this domain the transport process becomes essentially one-dimensional.

Rn too unsecure as a tracer for groundwater residence times (P343; P348, line 24; Table 2) The referee objected that radium as the source of radon varies much along the flow path of downwelling river water. We added text from earlier work to highlight, under which conditions the theory for Rn to be used as a groundwater tracer holds (paragraph before Eq. 14). To underline, we referenced work that successfully used this method.

Assumptions on the transfer of heat in granular media (P339/340, P347) The referee objected that no statement was made about the assumption for heat transfer properties and that they are uniform along the assumed flow path length, nor were values given. We now give explicit values on thermal properties and how they lead to certain, more

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or less uniform retardation factors of temperature (see paragraph following Eq. 7). Retardation is assumed constant.

Data accuracy and uncertainty (P347, line 9) The referee objected too many claims of accuracy and the need to define uncertainty in estimates. Rigorous uncertainty analysis was applied in the analysis of seasonal signals. Requiring that the sum of squared residuals of the fitted temperature time series meets its expected value, we computed the epistemic error of the measurements. From these, we determined the accuracy of the estimated temperature travel times by linearized error propagation.

Screened sections of wells (P345, line 15; P346, line 3) Some smearing in screened or slotted sections of wells is inevitable in the coarse aquifer materials of alpine alluvium. The water table was known to fluctuate by about 2m, and we wanted to tap the top groundwater layer. We assume that the errors in temperature measurements from mixing of ground water from different depths within this maximum of 2m are not significant for the analysis.

SPECIFIC REFEREE'S COMMENTS

P328, line 1. Remove "," after "show" done.

P339. The heat transfer equation used ignores thermal dispersivity. The authors need to comment (and justify) why they have neglected this. Longitudinal dispersion and heat conduction are mathematically interchangeable. In the previous version we had merged these processes in an effective heat conductance. Now, to reduce confusion, we merge them in an effective temperature diffusivity (which has contributions from thermal conduction in the aqueous and solid phases and from dispersion). See paragraph following Eq. 3.

P340. The heat transfer properties are assumed uniform over path length x. Justify. That is not true. They are assumed uniform only in the derivation of Eqs. 9 10. See additional explanations in the paragraph following Eq. 7.

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P340. Why use “s” as frequency? “f” is the universal symbol for this. In Fourier analysis, “s” is the standard symbol for the frequency. But we had no problem changing to “f”.

P343. It is assumed that the radon source is uniform along the path length. This is a bold assumption and needs to be justified. Major point in the General Comments section, see above.

P345, line 15. Why use a “2m length” screen section? This appears far too long for point sampling (important for the temperature signals). Major point in the General Comments section, see above.

P345, line 15. How do the authors account for the affect of changes with the water column? Major point in the General Comments section, see above.

P345, line 23. It appears that the river temperature series is obtained at only one location at site1 (and not at site2). How do the authors know that is doesn’t vary within a site and between sites? With respect to the placement of the logger in the river, we assumed that local variability smears out local surface water temperature variations.

P345, line 28. The reach is “100m” in the figure, not “400m”. It is 100m, corrected in text.

P346, line 3. 0.2m is still a long section for point measurements. Again, how do the authors justify this? Major point in the General Comments section, see above.

P346, line 12/13. The last sentence needs to be expanded. Do the authors mean that some of the loggers failed and they only have shorter periods for all loggers except 1,5 and 6? Yes, the loggers failed and had shorter measurement periods. This has been incorporated in the text.

P346. Explain the scatter in Figure 2 for the stream. It looks as though the authors have stream data for a very limited period, or that during a particular period there was more scatter. The figure does not really show the data logged period well. We confirmed this

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explicitly and improved the legibility by adding text in the figure caption.

P346. Need to give sample depths in a table so that the reader can interpret depths of the series shown. We added the depth placement of the loggers.

P347, line 1-8. I don't fully understand the reasoning here. It looks to me as though the processes that lead to this shift must be accounted for. We assume that this shift originates from mixing of infiltrated river water with local recharge.

P347, line 9. What is the "accuracy of 0.4 days" based on? More information is needed on this. Do they mean errors based on assumed processes? Major point in the General Comments section, see above. See also added text in the last paragraph before Section 4.2

P347. No heat transfer parameters are given and no statement about the assumptions of uniformity are given. See our response to referee's first comment of P340.

P347. What about 3-dimensional flow (e.g. river - sediment - river flow)? The assumptions must be explicit. Major point in the General Comments section, see above.

P348. Equation (15) must assume a constant velocity. But the authors state in the manuscript that the velocity changes over time! The implicit assumption of steady-state flow, which is clearly not given over the time period considered here, gave rise to a comment about the fact that the time shifts of maximum correlation are indicative for the effective transfer of temperature, averaged over various flow regimes, and weighted by the magnitude of the signal transferred at a given time. See paragraph following Eq. 15.

P348, line 12. Why compare high and low frequency estimates when those from low frequency data have been discounted? The two different frequency estimates seem to us to be clearly separated. We confirmed this in the text.

P348, line 24. Table 2 does not show the "sulfate and radon data" - it shows estimates based on these data. The data are needed, however, and more information to allow the

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reader to assess the validity of these estimates. It is naïve to assume that residence times can be extracted from radon data alone without making very bold assumptions about processes. Besides the original concentration data, Table 2 shows also the interpretation: end-member mixing rations, in the case of sulphate, and residence-time assessments from Equation 13. We clarified this in the figure caption.

P350, line 1/2. How to the authors know that the minor flood lead to removal of "clogging layers"? Statement omitted because we do not know the initial state of the riverbed.

P350. Some comments on the water levels in Figure 5 are needed. Also, the figure needs to show the levels clearer (to differentiate and label different sites). The humps in the water-level recordings were correlated in the text with temperature changes, and the caption of Figure 5 was clarified accordingly.

P350, line 23. Why was a well used as a means of getting river temperature? We explained this in the text with the logger in the river, which was misplaced for the purpose here.

P350, line 26. Why assume a unit hydraulic gradient? Hydraulic gradient was changed to a more realistic value, and text was adapted accordingly.

P350, line 28. River bed sediment hydraulic conductivities will vary over a much wider range! Is Landon et al. referring to the same sites here? same as above. Reference omitted.

P351, line 1-13. It is argued that temperature alone should not be used. It appears that it is for site 2 ! Analysis of the 2nd site relies indeed exclusively to information about temperature, although we state that further information is necessary. We conclude from the uncertainty in the temperature data that further information is required. Major point in the General Comments section, see above.

P352, line 9. The effect of ignoring multiples of 24 hours is not a conclusion as it

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has not been discussed until this point. It should, however, be raised earlier and the implications explained. done.

P352, line 17-21. Again, the authors say that temperature should be used with other tracers. But they don't for site 2! How can this be a conclusion??? Analysis of the 2nd site relies indeed exclusively to information about temperature, although we state that further information is necessary. We conclude from the uncertainty in the temperature data that further information is required. Major point in the General Comments section, see above.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 335, 2006.