

Interactive comment on “Characterization of spatial heterogeneity of groundwater-stream water interactions using multiple depth streambed temperature measurements at the reach scale” by C. Schmidt et al.

C. Schmidt et al.

Received and published: 9 August 2006

The authors are grateful to the reviewer for his helpful comments on the initial manuscript. The reviewer raised the critical questions in the paragraphs given below. The authors would like to particularly focus on these paragraphs.

4) "Are the scientific methods and assumptions valid and clearly outlined? The authors assume one-dimensional, vertical flow through the sediment, but discussion of hyporheic flow paths in the introduction and elsewhere, suggestions that the authors anticipate that non-vertical flow is important at their site. Also, the issue of heterogeneity is not explicitly addressed by a one-dimensional, analytical solution to the problem.

This is why many researchers feel physically-based, simulation models (such as, Sutra, Tough2, or vs2di) more correctly represent the streambed hydraulic properties."

The purpose of the one-dimensional approach presented in this study is to identify spatial patterns of stream- groundwater interaction and to quantify the water fluxes across the streambed. The one-dimensional approach constraints the quantification of non-vertical (hyporheic) flow in the streambed. The focus of our study is on flow from groundwater to surface water. Only a few observed temperature profiles indicate downward flow in very low magnitudes ($\leq 10\text{L/m}^2/\text{d}$). On the other hand hydraulic gradients between the aquifer and the stream indicate a gaining stream. We were discussing these findings as possible hyporheic flow within the streambed. Maybe this was misleading because we do not consider hyporheic flow is an important process at our site.

In this study spatial heterogeneity is addressed by the spatial differences of water fluxes across the streambed. In the way we understood and investigated the heterogeneity of stream-groundwater interactions, the one-dimensional approach is appropriate and was successfully applied.

6) "Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? No, the description of the field installation of equipment needs substantial improvement. For example, were 140 probes installed, or was one probe inserted in 140 separate locations? Lines 13 through 25 on page 1424 require substantial editing and elaboration."

We agree that the description of the field methods needs elaboration; we will try to improve that section. The streambed temperatures were measured with one probe containing containing 5 temperature sensors. The probe was temporarily inserted into the streambed at 140 locations. At each location the temperatures were simultaneously logged at 0.1 m, 0.15 m, 0.2m 0.3 m and 0.5 m depths below the streambed surface. The resulting dataset consists of 140 temperature profiles measured at 140 locations

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(at 5 depths at a single time for each location). The measurements were taken at two parallel longitudinal transects along the reach. The general spacing between the observation points along one transect was 3 m but it was refined if high temperature differences occurred between two points

11) "Is the language fluent and precise? Yes, except for the use of the word 'surrogate' in multiple locations in the text. The authors state that temperature can be used as a surrogate for head and hydraulic conductivity. More correctly, time-series measurements of streambed temperature at multiple locations coupled with an appropriate heat and water flux model provide estimates of water flux as an alternative to measurements of head and hydraulic conductivity. Also, in the introduction (page 1420, line 21) the use of the phrase 'different ways' is too vague."

We agree with the reviewer and will reword the phrases using "surrogate".

13) "Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? Figure 4 is both detailed and important, and one would hope that it is presented in a much larger format in the final publication. It was impossible to see many important characteristics in this 'postage stamp' presentation of the condensation of the entire research effort. A 1:1 one-to-one plot of the slug-test derived hydraulic conductivities compared with the temperature based estimates would be a potentially nice graphic."

We will include a one to one plot of Darcy's law and temperature derived fluxes in the revised manuscript.

We will include a larger version in the supplementary material and we hope that the format of the figure will be increased in the final publication

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 1419, 2006.

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