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Discussions

Interactive comment on "Limitations of fibre optic distributed temperature sensing for quantifying surface water groundwater interactions" *by* H. Roshan et al.

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Dear Dr Bakker,

We thank you for your question about the difference between our paper "Limitations of fibre optic distributed temperature sensing for quantifying surface water groundwater interactions" by Roshan et al. and that of Selker and Selker (2014). In brief the Selker and Selker paper seeks via flume experimentation to: "explore the interacting impacts of details of seep velocity, stream flow rate, bed texture, and degree of burial or probe coverage upon the magnitude of thermal signals at the sediment surface or up to a few centimetres below that surface . . .” and “. . .to identify conditions that might render the measurements either ineffective or relatively robust for seep detection” cited from Selker and Selker (2014). In summary we (Roshan et al.) systematically explore, via flume experimentation, the combined effects of stream flow rate, groundwater outflow rate and source temperature differences (i.e. between surface water and groundwater) on the detectability and quantification of groundwater flow. We establish a groundwater/surface water flow ratio threshold below which temperature detection of groundwater discharge and flow quantification by DTS are no longer reliable. Finally we propose a correlation that can be used for initial analysis of field DTS data. Both papers acknowledge the lack of DTS testing under controlled conditions in the literature and try to explore the capabilities of fibre optic DTS in a controlled flume environment. Thus superficially the two papers appear to seek similar goals using similar flume experimentation; however, as pointed out below the two papers are fundamentally very different in a number of ways:

a)For the temperature detection we used 750 m of fibre optic cable in a coiled configuration to increase the spatial resolution to about 0.017 m (compared to the standard resolution of about 1 m for a straight fibre optic cable). This allowed us to scale the problem to a 7 m flume with a 0.3 m groundwater outflow section. The field equivalent would be a groundwater seepage zone of about 32 m (0.3 m x 750 m/7 m). In contrast to our work, the work by Selker and Selker (2014) do not use fibre optic cables at all. Two discrete conventional temperature probes are used instead to represent the DTS cable. Supposedly, as stated by the authors, these probes are placed in locations representative of groundwater seepage. Proof of the appropriateness of these locations was not provided in their paper (see potential implications of this below).

b)In Selker and Selker (2014) the entire 1.5 m of the flume length (bar the inlet and outlet sections) is subject to groundwater seepage from the bottom up through a porous bed (so representing diffuse groundwater seepage along a stream). In our work only a 30 cm section of the flume floor (of the total flume length 7 m) is open to discharge, so a situation more a kind to a discrete spring discharging through the streambed. As very clearly shown by Norman and Cardenas (2014) in their experimental flume work, whenever a porous bed is included in a flume with surface water flow, a hyporheic circulation cell is set up within the porous media: i.e. surface water will enter the porous bed at the upstream end and exit the bed at the downstream end. Norman and Cardenas (2014) further showed how this altered the heat distribution in the porous bed and thus create variable temperatures along the bed surface water boundary. Based on the Norman and Cardenas work a hyporheic circulation cell should be expected in the experiment by Selker and Selker (2014). However, Selker and Selker do not discuss this nor demonstrate how this may have affected their temperature measurements or their conclusions! In contrast, in our flume experiment our temperature measurements are continuous along the flume from 1.85 m upstream of the groundwater discharge zone to 4.85 m downstream of the discharge zone. Since we capture the entire discharge zone with our continuous temperature measurements we do not need to consider the details of this hyporheic exchange in our analysis, however, we do show that it matters: the groundwater discharge at high surface water flow rates or low groundwater discharge rates are displaced to the downstream end of the discharge zone due to the hyporheic exchange.

c)A weakness in the Selker and Selker (2014) paper is that they do not try to quantify the effect of each physical parameter on the resulting temperature difference and they venture no further than to make qualitative statements: i.e. provide qualitative indications on whether the discharge of groundwater with a different temperature can be detected or not and the qualitative effect of stream bed texture and whether the sensors are buried or covered. In contrast, we have focused on quantifying the limit of detection of groundwater discharge (as a ratio of groundwater to surface water flow) by systematically varying surface water and groundwater velocities and varying the temperature difference between the surface water and groundwater sources.

d)We also provide a correlation for estimating the groundwater discharge velocity based on FO-DTS temperature measurements. Such a correlation is useful for converting temperature field data into discharge fluxes. However, we acknowledge that this correlation has been obtained in a well-controlled flume experiment with a well-defined outflow zone (i.e. the equivalent of a spring). Its application to field settings may be limited for a situation of spatially continuous diffuse seepage and additionally influenced by uncertainty in the parameters due to heterogeneous field conditions. For such conditions a total heat balance on the stream may be necessary to tease out the groundwater component from temperature measurements, which is beyond the scope of this paper.

In conclusion, both papers contribute valuable information and insights into the problem of estimating groundwater discharge via temperature measurements. However, we do believe that our work is more quantitative and comprehensive compared to that of Selker and Selker (2014) and will provide other researchers with insights into designing FO-DTS field campaigns to detect groundwater outflow and help with the interpretation of FO-DTS field data from streams.

Kind regards

Hamid Roshan and Martin S. Andersen

On behalf of all authors

Norman and Cardenas (2014): Heat transport in hyporheic zones: an experimental study. Water Resources Research, 50, doi:10.1002/2013WR014673.

Selker, F., and J. S. Selker (2014), Flume testing of underwater seep detection using temperature sensing on or just below the surface of sand or gravel sediments, Water Resour. Res., 50, 4530–4534, doi:10.1002/ 2014WR015257.

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