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Hydrology and Earth System Sciences Discussions

Interactive comment on "Investigating patterns and controls of groundwater up-welling in a lowland river by combining fibre-optic distributed temperature sensing with observations of vertical head gradients" *by* S. Krause et al.

Anonymous Referee #1

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General comments

This manuscript aims to use 2 complementary measurement techniques to better understand spatial and temporal dynamics in surface water-groundwater exchange in a lowland river. The installed piezometers give information about the direction and strength of the vertical hydraulic gradient (VHG) while FO-DTS gives information about locations of upwelling water. Because vertical hydraulic gradients can be caused by either a low hydraulic conductivity or by a large flux, it gives no conclusive information about upwelling water. FO-DTS gives information about upwelling water, but it does

not give information about the structure causing the upwelling. The authors show nicely that by combining the two methods the results are more conclusive. This is novel and therefore worth publishing.

However, improvements should be made especially in the writing part: Many things are inconsistent within the manuscript. For example, In Eq (3) the authors define sd($A_T(x_i)$), while in the second half of the manuscript they call it STDEV of temperature anomalies. Another example is that they mentioned that they did fieldwork between June and August 2009, but in Table 1 it is shown that at 21/5 they were also in the field. See below for more examples. In principle each of these flaws are minor, but in my opinion these are so abundant, that it adds up to more than minor revisions. Also many long sentences are used that makes it sometimes difficult to understand the sentence in one reading. Splitting the sentence in 2 separate ones will improve the readability. See below for some concrete examples.

Another point I miss is that no analysis is performed on loosing stream conditions. In 4.3.3 the authors state that this may be interesting to look at, but they did not do it although they had the data for this during and after the heavy rainfall at the end of June.

Specific comments

P338: Abstract: Make clearer why FO-DTS is not sufficient to explain surface water-groundwater exchange. Now it is only clear why VHG measurements are not enough as a single measurment.
P339 L14: In the first half of the manuscript (i) and (ii) are used as counters, while in the second half (a) and (b) are used. Please be consistent throughout the manuscript.
P340 L21-26: This part does not fit in the Motivation section. It is the state of the art.
P342 L8: Hoes et al. 2009, also uses FO-DTS to identify upwelling water in large water bodies.

P344 L19-21: It is difficult to understand this sentence: please rephrase.
P344 L22: How far is the Keele meteorological station from the site?
P345 L7: Make clear that the seven tubes are only used to see if water could be extracted from a certain depth, and that this data is used to verify! if upwelling water is indeed blocked by a peat or clay layer.
P345 L22: The Raman stokes are nearly temperature independent.
P345 L25: Is the 0.05 °C the precision you obtained or is it given by the manufacturer? With a time interval of 10 s (as mentioned on page 346) I assume the precision is lower.
P345 L26: Mention the temporal resolution here as well (instead of on the next page).
P347 L21: Is the spatial average an average over all temperature points along the part of the cable that is in the water?
P347 L26: $\overline{T(x_i)}$ should be $\overline{T(x)}$. Otherwise it can only be an average over time.
P348 L4: From this point on (a) and (b) are used instead of (i) and (ii). Please be consistent.
P348 L4-5: Changes in hydraulic gradient does not always imply larger fluxes. If the upwelling water is blocked by peat or clay layers this will not be the case.
P348 L5: 'Temperature gradient' should be a 'difference in temperature', since a gradient implies dividing by e.g. a distance.
P348 L9: same as P347 L26.
P348 L13: Explain what (x_{it}) is and use A_k instead of A_T and clarify that subscript k means either temperature or VHG.
P349 L2-5: This is another sentence with which I had difficulties to understand. Please rephrase or make 2 sentences out of it.
P349 L23-24: Temperatures were indeed higher at the end of the observation period, but no maximum is present yet. The conclusion that the time lag is several weeks is thus a bit premature, since it can also be a couple of months.
P350 L13: Again: the 5°C is a temperature difference and not a gradient.
P350 L14: If the temperature difference exceeds 5°C most of the time, is the average

of 3.1°C (mentioned in L3) correct?
P350 L20: Figure 6 is only partially supporting the mentioned range between 0 and 0.92, since it only shows gradients between 0.05 and 0.6.
P351 L25: Do you mean P24-P26? P27 is further away from the spatial mean.
P352 L1: Is the spatial temperature variability of 2.3 degrees the difference between the boxplots at 0m and ∼130 m? This statement can only be true if both temperatures were measured at the same moment. Otherwise it is a spatial and temporal variability.
P352 L6: Is STDEV the same as Eq (3)? Be consistent with the symbols!
P352 L7: Are the mean and stdev in Fig 9 the same points as the lines in Fig 8?
P353 L14: Change sentence to: Observed groundwater levels generally exceeded ....
P353 L14-25: A Large part of this paragraph is results and should go to the result section.
P354 L2: There is not only upwelling water during the study period. But Fig 6 shows temporal averages which are indeed upwelling.
P354 L7: I would remove the reference to Fig 2.
P354 L11: replace 'for instance, as' with 'because'
P357 section 4.3: Here the authors make clear why FO-DTS measurements alone are not enough. However, the reason why VHG is not enough as a standalone measurement is mentioned in section 4.1. For consistency, either mention them both in 4.3 or mention the FO-DTS shortcomings in 4.2.
P356 L1: Where does the 0.05°C come from?
P356 L12-14: I suggest replacing 'Furthermore ... groundwater inflow' with 'Furthermore, since the temperature anomaly patterns prove to be temporally persistent, it can be assumed that groundwater inflow is also persistent'
P356 L19: What is topography driven temperature variability?
P356 L24-27: This part fits better in section 2.1.
P357 Section 4.3.1: I suggest to add a table or a point by point list to better represent the 4 different cases: small VHG and small dT; large VHG and small dT; small VHG and large dT; and large VHG and large dT and explain what the flux and structure

should look like. That will make it easier for the reader to recall the different cases when they are discussed in the following sections.
P358 L3-6: This is a repetition of 4.3.1. and can be left out.
P358 L14: replace'. . . in piezometers P5, P9 etc.' with '. . . in these piezometers'
P359 L10: Isn't the stream loosing during peak flow at 31/7?
P359 L10-14: This sentence is difficult to understand: Does this example refer to winter conditions (although summer is mentioned here as well)? And are 'similar groundwater- surface water thermal gradients' similar to winter conditions or to the observed gradients?
P366: The reference to Selker et al., 2006b is missing
Table 1: Piezometer IDs are P1, P2 and no T1 and T2.
Table 1: Be careful with the '–' sign, since it can be interpreted as a minus sign. I suggest using the symbols as mentioned in Eq 1 and 2.
Table 1: What does '(nearest)' mean in 'DTS – difference to spatial mean'?
Fig 1: What are the dotted lines close to GW1 and GW10?
Fig 2: How many cores have been used to draw the conceptual model?
Fig 3: The DTS has no sampling points. It gives spatial averages over 2 m (this is a result of the length (in terms of time) of the laser pulse send through the fiber.
Fig 4B: I suggest showing the precipitation in mm/d, so it is easier for the reader to see the total amounts.
Fig 8: Is stdev the same as STDEV and Eq 3? Again, be consistent.
Fig 8B: Indicate the relative location of the cable by either adding locations of piezometers at the x-axis or by adding distances in Fig 3B.

Technical corrections

P341 L28: 'cause measurable in temperatures', should be 'cause measurable anomalies in temperature'
P344 L17: 'Fig 2' should be 'Fig 2a'
P344 L19: In table 1 and on the next page it is shown that already on 21/5 field data

has been collected.
P346 L19: According to Table 1, the surveys were carried out between 23/7 and 19/8.
P346 L26: Fig 7 should be Fig 6.
P347 L27: locations should be location
P348 L3: as result should be as a result.
P348 L10: piezometers should be piezometer.
P354 L19: replace 'sections – P1-3 + P25-27'with 'sections: P1-3 and P25-27'
P356 L1: remove '>'
P358 L23: indicated should be indicating
P359 L15: move 'hence' in-between 'and'and 'the'.
P358 L17: remove the parenthesis.
Figure 2: Change 'conceptual' into 'perceptual'?

References:

Hoes, O. A. C., Luxemburg, W. M. J., Westhof, M. C., van de Giesen, N. C., Selker, J., 2009. Identifying seepage in ditches and canals in ploders in The Netherlands by distributed temperature sensing. Lowland Technology International 11 (2), 21–26.

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