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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Investigating the spatio-temporal variability in groundwater and surface water interactions: a multi-technical approach" *by* N. P. Unland et al.

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Response to comments, anonymous reviewer #2

We thank this reviewer for their comments and outline our responses below:

General comments

1. Due to the absence of groundwater bores in the surrounding area, the detailed patterns of regional groundwater cannot be determined. The bores used in this study are within a few meters of the Tambo River, which is gaining, and in such situations groundwater flow will be approximately perpendicular to the river (Larkin and Sharp,

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1992; Winter, 1999).

2. As indicated in response to reviewer #1, the authors concede that the results section is more lengthy than required; we propose to use a table or figure to summarize the data and shorten the text.

Specific comments

The reviewer made several specific comments that we will address in the revised version of the paper.

Pg 3796 line 14. It was discussed in section 4.3 that the infiltration of river water into the river bank would dilute the concentration of Cl and activity of 222Rn of the water returning to the river. To account for this, sampling of groundwater from river banks was undertaken. However, the volume of river water infiltrating the river bank may vary at different locations along the Tambo River. If this is the case, the use of only 3 groundwater sampling locations may not accurately characterize the chemistry of groundwater entering the river. The sentence will be clarified to:

"While groundwater sampling from the bank of the Tambo River was intended to account for the dilution of tracers via bank infiltration, variations in bank infiltration along the Tambo River may not be accounted for by only 3 sampling locations, limiting the use of Cl as an effective tracer".

Pg 3796 line 26. Erroneous "(Luc, 2004)" reference change to "(Lambs, 2004)".

Pg 3826 line 12. Erroneous reference "Luc, L.: Interactions between groundwater and surface water at river banks and the confluence of rivers, J. Hydrol., 288, 312–326, 2004." to be removed from reference list.

Pg 3797 line 28. "Cook et al., 2003, 2006, 2012" to be changed to "Cook et al., 2003, 2006; Cook, 2012".

Pg 3798 line 4. Will add "temporal variability" to the strengths and weaknesses of

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tracers.

Pg 3798 line 9-12. Degassing is an important process in controlling the 222Rn activities in surface water, this will be emphasized.

Pg 3798 line 12. "(e.g. Cook et al., 2006, 2012)" change to "(e.g. Cook et al., 2006; Cook 2012)".

The grammatical and spelling mistakes outlined (page 3798 to 3800) will be corrected.

Pg 3800 line 9. "uncommon" will be replaced with "less common".

Pg 3801 line 2. "gauging" will be replaced with "river gauging".

Pg 3801 line 7. The river velocity was calculated by dividing discharge volume at the gauging station by the by cross sectional area of the river at the gauging station.

Pg 3801 line 14. EC precision is ± 1 %.

Pg 3801 line 14. Temperature precision is $\pm 0.1^{\circ}$C.

Pg 3801 line 14 DGPS precision is <1 cm for installations and water levels, < 2cm for surveys.

Pg 3801 line 22. Uncertainty in gradient calculation is ± 1 cm.

Pg 3801. As it is not possible to access the river over its entire length, Google Earth was used to approximate river widths. When compared with widths measured here and elsewhere at bridge crossings, this technique provides an acceptable accuracy.

Pg 3802 line 13. During each campaign, the river and bore sampling were carried out over a 1-2 day period. We will note this in the revised text.

Pg 3803 line 6. It is more appropriate to report 222Rn activities in Bq/m3 in these types of studies. If Bq/L is used for concentration, then terms such as the flux from the hyporheic zone or the evaporative flux on the right hand side of Eq. (2) have units of Bq/L.m2/day; with concentration in Bq/m3 the units are Bq/m/day (which is more

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informative). In the literature, 222Rn activities are variously reported in Bq/L, mBq/L, Bq/m3, and counts per minute (CPM) and there is no dominant convention.

Pg 3803 line 8. These are uncertainties based on 4 replicates.

Pg 3803 line 11-13. The samples were collected in air tight containers and kept cool.

Pg 803 line 23. Space to be inserted between Bq and m-1.

Pg 3804 line 6. qh represents the volumetric flux both into and out of the hyporheic zone assuming that the hyporheic zone is at steady state. As the reviewer noted, there is no impact on the net downstream flux; however, while this process does not add or remove water to or from the river, it is important for the Rn mass balance as the water flowing through the hyporheic zone will derive 222Rn from emanation. This sentence will be restructured to clarify this point.

Pg 3804 line 9 "(Wagner and Harvey, 1997; Runkel, 1998)" corrected to "(Runkel, 1998; Wagner and Harvey, 1997)".

Pg 3827 "Runkel, R. L.: One-Dimensional Transport with Inflow and Storage (OTIS): A Solute Transport Model for Streams and Rivers, U.S. Geol. Surv. Water Resour. Invest. Rep., 98–4018, 1998." To be added to reference list.

Pg 3804 line 15. "O'Connor and Dobins (1958)" corrected to "O'Connor and Dobbins (1958)".

The results section will be summarized as indicated above (General comment 2). Standard deviations (1σ) will be included where appropriate and terminology of "to" shall replace "-".

Pg 3805 line 9. "summarize" will be changed to "reports".

Pg 3806 line 23. Term "period" to be inserted.

Pg 3807 line 25. The temperature and EC profiles were only conducted during Febru-

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ary 2011 and March 2012 sampling periods; this is indicated on pg 3801 line 12.

Pg 3808 line 13. Space insert between “and” and “15”.

Pg 3808 line 20 onwards. As the reviewer points out the uncertainty of 0.1°C during temperature profiling means that a recorded change of 15.3 to 15.5°C is within the level of uncertainty and cannot be considered and increase. While this does not change the overall interpretation of the trends, the terminology will be revised as suggested.

Pg 3809. “to” will replace "-".

Pg 3810 line 7. The term “period” will be added.

Pg 3810 line 10. The Cl concentrations at location 3 were higher than those at location 2, this will be highlighted.

Pg 3810 line 19-21. The average 222Rn activities ranging from 4610 to 2320 Bq/m3, will be included.

Pg 3811 line 21. The study stretch will be specified as being between 40.4 and 18.6 km.

Pg 3811 line 23. Year “2011” to follow August to clarify sample date.

Pg 3811 line 25. The term “respectively” will be added in parenthesis.

Pg 3812 lines 20-22. Regional groundwater salinity maps for the region (DPI, 2012) indicate lower salinities in the north of the basin, becoming more saline to the south of the basin closer to the discharge points of the Tambo and Nicholson Rivers. Groundwater at Location 2 on the Tambo River is more representative of the salinity of groundwater neighboring the study section of the Nicholson River as indicated by these maps, and in the absence of regional groundwater bores Cl concentrations from this location have been used. This was omitted from the original article and will be included.

Pg 3813 lines 3-9. The uncertainties in mass balance calculations are discussed more

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thoroughly in section 4.2 and have been left there to retain the desired article structure.

Pg 3813 line 23. “this area” refers to the region at ∼29 km as will be specified in the text.

Pg 3814. Term “to” will replace “-”.

Pg 3814 line 20. Term “sharp” to be removed from text.

Pg 3816 line 5. Reference to “O’Connor and Dobins” to be corrected to “O’Connor and Dobbins”.

Pg 3816 line 10. The term “less apparent” refers to the trends in the gas transfer models during different sampling periods observed for the Tambo River. There is less variation in k values for the Nicholson River as the river velocity of the Nicholson River varies less between sampling periods than the Tambo River. This point can be clarified.

Pg 3816 lines 15-18. While uncertainties in k alter the calculated groundwater they do not alter the interpretations of the distributions of gaining reaches or the conditions under which increased groundwater discharge occur.

Pg 3818 lines 1. “Cli” will be replaced with “Ci”.

Pg 3818 lines 13-15. The uncertainties in the characterization of groundwater end members, and the subsequent uncertainty in groundwater flux estimates, may account for some of the calculated discrepancies in by Cl and 222Rn mass balance calculations. This will be discussed more fully in the text.

Pg 3819 lines 23-25. Edit sentence to: “While groundwater near the Tambo River was used to characterize the groundwater entering the Nicholson River, results suggest that the groundwater end members used may reasonably characterize the groundwater entering the Nicholson River”.

Pg 3819 line 21. Sentence change to “Groundwater discharge estimates to the Nicholson River by Cl mass balance ranged from 654 to 38 300 m3/day while 222Rn mass

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balance estimates gave discharge estimates of 88.4 to 61 100 m3/day".

Pg 3819 lines 21-22 and 25. Repetition of "this suggests" to be deleted.

A conceptual model will be attempted to help visualize the processes described in text.

Pg 3820 line 14-15. Elevated groundwater discharge occurred 5 days after significant rainfall and flooding in August 2011, indicating a groundwater response in less than 1 week. This will be indicated in text.

Pg 3821 lines 5. Sentence revision to "This study shows that while two rivers within the same aquifer system may vary considerably with respect to discharge volumes, groundwater may still represent a similar proportion of the total river discharge in each case".

Reference adjustments outlined by the reviewer will be made as indicated above.

References missing in text will be added where appropriate or omitted.

Table 1. "Aug 12" change to "Aug 11". "Mar 10" change to "Mar 12".

Figure 5. Words "February" and "March" to be corrected.

Figures 8 and 9. Uniforming the y axis between figures will limit clarity in the distribution of gaining reaches. As this is the intended purpose of the figures the authors would prefer to keep the axis as in the current figure.

References

<www.dpi.vic.gov.au>

Larkin, R., Sharp, J., 1992. On the relationship between river-basin geomorphology, aquifer hydraulics, and ground-water flow direction in alluvial aquifers. Geological Society of America Bulletin, 104(12): 1608-1620.

Winter, T.C., 1999. Relation of streams, lakes, and wetlands to groundwater flow systems. Hydrogeology Journal, 7(1): 28-45.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 3795, 2013.