

Interactive comment on “Halon-1301 — further evidence of its performance as an age tracer in New Zealand groundwater” by Monique Beyer et al.

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Received and published: 28 May 2017

General Comments

This manuscript massively extends the data set for Halon 1301 in New Zealand (>300 measurements) compared to the 2015 paper in HESS of the same authors, and compares its usability with tritium, SF₆ and the CFCs (CFC-11, CFC-12, CFC-113). The analysis uses a lumped parameter (LPM) approach – the exponential piston flow model (EPM) with an evaluation of mean residence time (MRT) and volume ratio (E/PM) for this model – to assess agreement in “groundwater age” as inferred by the different tracers. It is very well presented and besides the obvious demonstration of the usefulness of H1301 the article also shows some valuable new approaches in demonstrating and

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quantifying agreement in lumped parameter model results. It is clearly worth publishing with minor revisions in HESS.

Specific Comments

Although using only one specific shape of an age distribution (the EPM), the paper does a good job in evaluating comparability of LPM results for different tracers for the same water sample as “agreement in inferred age”. Of special value here is the 2d-plot of the E/PM parameter versus the MRT for different tracers if the model results are in the 1-sigma range of the measurement. This is a very useful way to display these results that I have not seen before. The developed metric, however, is worth discussing in more detail.

While I completely agree not to use MRT only, I have a problem with the attempted metric. No overlap of the two data clouds in Fig. 4 simply means that the two tracers give differing results which cannot be brought into a 1-sigma agreement with any parameter combination. So what is the meaning of the “Euclidian distance between two data clouds”? And what is the “% difference in MRT and mixing parameter inferred with two tracers”? Is the percentage (distance divided by what?) taken from the MRT and mixing parameter of the two nearest points or from the whole axis? For example, if the nearest two point in figure 4 left have 20 and 30 years MRT, is the percentage in MRT then $(30-20)/(20)=50\%$? Or is it $(30-20)/100=10\%$?

Most of the following paper uses a 10% criterion on this distance as “agreement” (Fig. 6, 7, 9, 11, 12) which is misleading, because any percentage >0 means the two results actually disagree. Perhaps a better way for quantifying agreement or disagreement would be to use a 1-sigma and a 2-sigma evaluation. Overlap of the clouds generated with 1 sigma would be good agreement, overlap of clouds with 2 sigma still agreement with a certain smaller probability. No overlap of data clouds generated with 3 sigma would be clear disagreement.

In case of disagreement (e.g. 6% of the sites with SF₆ and ³H available) an evalua-

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tion of the uncertainty in recharge temperature, recharge altitude and excess air may be valuable – perhaps this would bring the results into agreement within the 1 sigma uncertainty of these parameters? Similar for H1301, since its dependency on temperature, altitude and excess air is different than for SF₆.

Technical Corrections

Attempting to determine a MRT of 150 years with the given tracers (P. 3 line 22) is too ambitious and does not acknowledge the high quality of LPM presentation of the rest of the paper. None of the discussed tracers is sensitive to water recharged prior to 1950 (not even with the high sensitivity reached by Uwe for tritium). This is 67 years, not 150. Even using MRT instead of “age”: an EPM with an E/PM of 0.1 (bottom row in plots of figure 15-20) and MRT of 75 years contains none of the tracers (all water in it is >67.5years old), and only <0.001 parts of water older than 120years. There is a good reason why all plots in Fig. 4, 8, 10, 15-20 have MRTs only until 100 years.

P.5 L16: Salinity may be negligible for groundwater in NZ, not so in other parts of the world (e.g. Australia).

In Figure 1 using the same colours for the symbols as in the pie chart would increase readability.

Figures 6, 7, 9, 11, 12 use “agree <> 10%”. This is a strange use of the symbols “<>”. I think a better way to express what you mean is “disagreement <10%”, see discussion above.

Figures 6, 7, 9, 11, 12 display the word “contaminated” which I assume has to be “contaminated”.

Figures 6, 7, 9, 11 12 would be improved by having colour in the pie chart and legend.

The low-MRT branch of tritium is invisible in Fig. 8 right and Fig. 10 left. Put that on top of the other plots.

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An explanation is needed why in Figure 15-20 the displays 53, 56, 57, 63-68, 134 show the whole area as blue. Uncertainty of H1301 measurement too large?

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2017-80, 2017.

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