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Hydrology and Earth System Sciences Discussions

Interactive comment on "The contribution of groundwater discharge to the overall water budget of Boreal lakes in Alberta/Canada estimated from a radon mass balance" *by* A. Schmidt et al.

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The objective of the study was to determine the groundwater discharge component in the hydrological balance of two lakes in the oil sand mining region of Fort McMurray in Alberta, Canada. To determine groundwater discharge rates the authors applied a radon balance technique which has proven to be very appropriate in similar settings (Stringer, 2004) as it can be very sensitive and gives flux rates representative of a larger area. With the Rad-Aqua one can measure radon in situ and with real-time results the user can vary the measurement parameters (for example the counting time)

to achieve appropriate minimum detectable activities (MDA). However, radon activities in Lake A were very low (<1 Bq/m3) and one wonders if a radon cryogenic extraction method which has significantly lower MDAs would have been a better technique for this lake. Although the RAD7 detector has vanishingly low background, stating that 0.5 Bq/m3 of radon was detected with confidence needs some proof. As the RAD-Aqua is not usually applied for measurements of such low levels of radon, a list of the measurement parameters such as counting time, temperature and the corresponding MDA should be included in the manuscript. The authors state that the surface water 222Rn is not supported by 226Ra dissolved in the water column because 226Ra was below detection limit. Was the surface water 226Ra measured with the same sensitivity as 222Rn? What was the MDA of the 226Ra measurement?

Using the parameters given in the manuscript I reproduced the groundwater discharge rate calculation for both lakes. I did not find porosity and water temperature and had to estimate the temperature by iteration until my atmospheric evasion rates matched the ones indicated in the manuscript. I assumed a temperature of 2 oC and a porosity of 0.5. I then used these parameters and calculated groundwater discharge rates using the advection-diffusion approach following Cable et al., 1996 and received very similar results, Lake A: advection rate of 0.01 cm/day resulting in a discharge of 336 m3/month, Lake B sandy area: advection rate of 0.196 cm/day resulting in 5645 m3/month and Lake B silty area: advection rate of 0.068 cm/day resulting in 37000 m3/month. For Lake A this is an acceptable agreement. For Lake B groundwater discharge from the silty area, which represents 95% of the lake bottom, significantly influences the final groundwater discharge budget. I wonder whether those discharge rates are real. Is it possible that groundwater discharge only occurs in the sandy area and the radon measured in the other parts of the lake is only a result of mixing with high radon water? How would the authors account for this mixing? Would that scenario change the total groundwater discharge rate for the whole lake? The other question is how much confidence we should have in assessing advection rates of 0.01-0.068 cm/day. Is the radon approach really sensitive enough to detect advection rates as low as 0.01 cm/day? I

agree with the authors' conclusion that groundwater discharge is insignificant for the water budget of Lake A. How about the silty part of Lake B? The authors assumed no seasonality in groundwater discharge rates. I think that is an incorrect assumption. Seasonality of groundwater discharge will depend on many factors, for example whether the lakes are recharged from a water table aquifer which would respond to rain patterns almost immediately or a confined aquifer with a slower response to climate variations. In any case, when groundwater discharge is compared to the overall water budget, one has to assume some variation. Therefore lines 20-23 on page 5004 should be worded more carefully.

Specific comments:

Page 4992, line 16: "...[radon] is transported with it through the aquifer." –or until it decays. Consider rewording as depending on the transit time radon may not be transported through the aquifer but may decay or re-equilibrate with 226Ra to a different activity.

Page 4992, line 21 and throughout the manuscript: "activity concentration" pick activity or concentration, using both is redundant

Page 4993, line 5: "...in a water column representative of the lake water body." The definition is incomplete as it does not consider uneven groundwater discharge through the lake bottom and inefficient mixing of the lake water.

Page 4995, line 25: "[radon] is in decay equilibrium with the radium..." it should be in radioactive equilibrium instead.

Page 5001, lines 10-13. Homogeneous pH and conductivity distribution does not necessarily mean complete mixing and pH may be influenced by other biochemical processes.

Table 2. This table implies that diffusion (Fdiff) was not considered for advection rate calculations for 1-A, 2-A, and 4-A. However, based on the math it was included in the

radon mass balance.

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