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Interactive comment on "Quantifying flood-water impacts on a lake water budget via volume-dependent transient stable isotope mass balance" *by* Janie Masse-Dufresne et al.

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While this paper is a detailed look at a small man-made (or influenced lake), it isn't clear what the overall usefulness is to others working on larger and more complex lake systems. The manuscript is overall relatively well written, but there are many parts that aren't always clear. Most importantly there is no discussion outside of the local issues of the lake, which makes this a very site specific study.

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There are also many line by line points that need to be made. These are as follows:

SC1-1. Line 43: The reference to Klove et al, 2011 is to Groundwater Dependent Ecosystems (GDE) and lakes are not the same thing as GDEs, they are a subset of GDEs in most, but not all cases. This reference should be something specific to lake systems. GDE also refer to streams wetlands and other non-lake surface waters. For example, Rosen 2015 would be a better reference. Rosen, M.R., 2015, The influence of hydrology on lacustrine sediment contaminant records. In Blais, J.M., Rosen M.R., Smol J.P. (eds) Environmental Contaminants: Using natural archives to track sources and long-term trends of pollution. Springer, Dordrecht. 5 – 33 p. https://DOI.org10.1007/978-94-017-9541-8

Answer: Done. We agree with the reviewer. The suggested reference will be used instead.

SC1-2. Line 44: "few decades"... references only list the last decade. You could add: Herczeg AL, Leaney FW, Dighton JC, Lamontagne S, Schiff SL, Telfer AL, English MC (2003) A modern isotope record of changes in water and carbon budgets in a groundwater-fed lake: Blue Lake, South Australia. Limnol Oceanogr 48:2093–2105 if you want to go back two decades.

Answer: Done. Thank you. The suggested reference will be used instead.

SC1-3. Line 56: "...but occur over a 1 km long area." Do you mean 1 km "wide" area? The length of the river or canal is of no importance, it is the width that will make it hard to measure flux. Please change to "wide".

Answer: Done. You are right. We meant 1 km "wide" area. This is to be corrected in the manuscript.

SC1-4. Line 58: "The democratization of isotope mass balances in Quebec..." What does the "democratization" of isotope mass balance mean? Was this auto corrected from the original word to be used. I hope so, as I had no idea that isotopes were political! Should the word be "demonstration"? Not really sure what is going on here.

Answer: Clarification. This is a concept we translated from French, but the Reviewer's comment made us realize that the meaning is not accurate in English. We wanted to convey the fact that isotopic methods are not widely used in Quebec (Canada) yet and that we could benefit from their application. As this is only a local implication, we opt to withdraw this sentence from the manuscript.

SC1-5. Line 60-70: It would be good to include Herczeg et al (2003) here as well as they determined changes in isotopic composition due to groundwater pumping, this also shows how transient changes can affect the isotopic composition of lakes.

Answer: Done. This publication is indeed very interesting and is related to our study. Herczeg et al. (2003) demonstrated the impact of various forcings, such as the rainfall variability, land-use changes and increased pumping rates, on the water residence time in the Blue Lake, in Australia. Note that the pumping corresponds to direct surface water abstraction (Lamontagne and Herczeg, 2002), and not groundwater pumping. Nonetheless, Herczeg et al. (2003) showed the importance of studying lake water budgets in order to identify potential governing forcing in order to secure water quantity and quality overtime, as lakes are important water resources for the production of drinking water. In that sense, the following material could be added to Line 43:

> *"…and to secure water quantity and quality overtime for drinking water production purposes (Herczeg et al., 2003)."*

SC1-6. Line 78: There is no hypothesis indicated in this manuscript. The objectives are clear but there is no indication of what mechanisms they propose may be important. A hypothesis should be added.

Answer: Done. Some information concerning our conceptual model would help to better understand the objectives of the developed model. We propose to add the following at Line 74:

> *"In this hydrological context, it was conceptualized that groundwater inputs to the lake are very limited, while flood-water inputs (via the surface) and groundwater outputs are governing the water balance during the flooding event. Contrastingly, as the water level of the lake decreased after the flooding event, it was assumed that groundwater inputs and surface water outflows were dominant over the lake water balance during low water level periods."*

SC1-7a. Figure 1. Water courses shown don't match up with the description. There is supposed to be one inlet and outlet to Lake A, but at least two inlets are shown (or outlets). Flow directions are needed on the other streams (canals?) shown.

Answer: Done. A description of the streams (or canals) in the southwestern part of Figure 1 b should be added. As the topography in the study area is nearly flat, the flow direction can evolve according to Lake DM elevation, similarly to S2. It is important to note that these streams are channelized (i.e., man-made). We propose to correct Line 91-92 to:

> *"Two channelized outlet streams (S2 and S3) allow water to exit Lake A and flow towards Lake DM. The flow direction at S2 and S3 can be temporally reversed. . ."*

SC1-7b. The reorienting of the North arrow is somewhat confusing, probably needed.

Answer: Done. The orientation of Figure 1 b can be adjusted to have both Figure 1 b and c in the same orientation (see submitted Fig. 1 with this response).

SC1-7c. All sampling is done in one corner of the lake, why was this done? Presumably the lake is well mixed? Samples taken near the shore, like LB-S1 could have some evaporation signature in them. Was this accounted for?

Answer: Clarification. Lake A is an actively mined sand pit. Access to the Lake was limited to this area due to logistical and safety issues. In this study, the horizontal variability of the waterbody was not assessed. However, Pazouki et al. (2016) showed that temperature, dissolved oxygen, pH and turbidity are very similar along four 10-meter vertical profiles (one in each corner) in Lake A. We suggest the following addition to Line 151-152:

> *"Additional field campaigns were conducted on February 9, 2017, August 17,2017 and January 25, 2018 in order to perform vertical profile measurements and water sampling at various depths (e.g. 2 m, 4 m, 8 m, 12 m and 15 m) at LA-P1 to LA-P2. Lake water sampling was only performed in the northern region of the lake due to accessibility and logistics procedures. As horizontal homogeneity has been previously demonstrated by Pazouki et al. (2016), the water samples were deemed representative of the whole waterbody."*

SC1-7d. If Lake DM really has a name (Deux-Montagnes), then the name should be put on the map with the (DM) in parentheses. One might also argue to use the French for the whole name, Lac des Deux Montagnes. Lake B also appears to be called Lac Val des Sables in google earth, is this not correct?

Answer: Moot. The Reviewer is correct; Lake B is called "Lac Val-des-Sables". The names "Lake A", "Lake B" and "Lake DM" were used to keep the location of the study site as anonymous as possible, due to an agreement with the Town. However, this comment clearly shows that it is easy to figure it out. Still, we prefer to use the names "Lake A", "Lake B" and "Lake DM" to facilitate the reading.

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Considering all the above, a revised version of Figure 1 is proposed (see submitted Fig. 1 with this response).

SC1-8. Line 116: "All water levels are reported relative to a reference water levels measured on February 9, 2017" One reference water level or many? Please fix, this is a combination of both.

Answer: Done. There is a reference water level (z=0) for each well starting on February 9, 2017. Considering this comment and SC1-10, we propose a revised version of Figure 2 (see submitted Fig. 2 with this response).

SC1-9. Line 118 change to ". . .over the Ottawa River watershed. . ."

Answer: Done. Thank you.

SC1-10. Line 125-126: "...synchronous with those of Lake DM (Fig. 2) from late February to late July 2017". How do you know water levels are synchronous from Late February when water level measurements weren't begun until April? This can't be known. Given the sparse data in figure 2, and the non-synchronous relation between the observation well and Lake DM in the autumn, this can't be conclusively known. In addition, some of the well peaks appear to actually occur before the lake level rises, which is a bit strange. In any case, more information is needed to be able to say this. It may be true for the flood period, but that would be expected. The low flow period doesn't appear to be completely synchronous. While it may be true that Lake DM controls Lake A water level during flood periods and/or high water periods, there is no data presented that shows that Lake A water levels are synchronous with Lake DM during low flow or low water levels. Clearly the groundwater is not synchronous during September to November.

Answer: Clarification and done. A hydraulic connection between Lake DM and Lake A only occurs when a topographic threshold (at 22.12 m.a.s.l.) is exceeded. During autumn, the water levels of Lake DM and VP are below this threshold, which explains why there is a different evolution for Lake DM and VP during this period. This information is not explicitly shown on the original version of Figure 2. Considering this comment and SC1-8, we propose to modify Figure 2 (see response to comment SC1-8) in which the water level is illustrated relatively to a known common datum (i.e., meters above sea level). By doing so, it is possible to graphically represent the periods of hydraulic connection between Lake A and Lake DM. In our opinion, this will facilitate the reading and help understanding of the hydrodynamic context. Furthermore, we added four manual measurements of the water level at Lake A. These observations confirm that the water level of Lake DM is not governing the one of Lake A during autumn (September to November).

Note that the absolute water level at the pumping well P5 is not known (missing information concerning the positioning of the Town's pressure logger). The water level at P5 could thus not be represented on the revised version of Figure 2.

SC1-11. Section 3.1 Field measurements section. There is no mention of calibration for the water level loggers. Without calibration how do you know they were synchronous or that they water levels were the same? Please give all the calibrations that were done on instruments and isotopic analyses.

Answer: Clarification. The following could complement Line 140:

> *"All the level loggers' clocks were synchronized with the computer's clock when launching automatic measurements for a 3-month period. This procedure was done via the Diver-Office 2018.2 software. Manual measurements of the water level were regularly performed to calibrate (relatively to a reference datum) and validate the automatic water level measurements."*

SC1-12a. Section 3.2 Water sampling and analytical techniques: Other than ion

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balances, was any other QA/QC done? This needs to be stated. In addition, were isotope measurements compared with standard mass spectroscopy? Ring cavity measurements have been shown to be in error in some cases and should be viewed with some skepticism unless comparison is made to standard mass spectroscopy or the methodologies listed below have been followed. See Wassaner et al (2014) and Sengupta (2014) for examples. Perhaps more detail about replicates and comparisons to mass spectroscopy measurements can be done to alleviate concerns over the accuracy of the ring cavity measurements. References: Sengupta, S., 2014, Pros and Cons of Laser Based Isotope Measurements of Water and Real Time Vapour Samples: A User's Perspective. Gond. Geol. Mag., V. 29 (1 and 2), pp.45-51 Wassenaar, L.L., Coplen T.B., Aggarwal, P.K., 2014 Approaches for Achieving Long-Term Accuracy and Precision of 18O and 2H for Waters Analyzed using Laser Absorption Spectrometers. Environ. Sci. Technol. 2014, 48, 2, 1123-1131.

Answer: Clarification and done. We agree that it is worth to provide more details on the analytical procedures. Thank you for questioning this point. Line 166-168 could be corrected to:

> *"1 ml of water was pipetted in a 2 ml vial and closed with a septum cap. Each sample was injected (1 microliter) and measured 10 times. The first 2 injections of each sample were rejected to limit memory effects. Three internal reference waters ($\delta^{18}O = 0.23 \pm 0.06$‰, -13.74 ± 0.07‰ -20.35 ± 0.10‰; $\delta^2 H = 1.28 \pm 0.27$‰, -98.89 ± 1.12‰ -155.66 ± 0.69‰; $\delta^{17}O = 0.03 \pm 0.04$‰, -7.32 ± 0.06‰ -10.80 ± 0.06‰) were used to normalize the results on the VSMOW-SLAP scale. A 4^{th} reference water ($\delta^{18}O = -4.31 \pm 0.08$‰; $\delta^2 H = -25.19 \pm 0.83$‰; $\delta^{17}O = 2.31 \pm 0.04$‰) was analyzed as an unknown to assess the exactness of the normalization. The overall analytical uncertainty (1σ) is better than ± 0.1‰ for δ^{18}O, ± 1.0‰ for δ^2H and ± 0.1‰ for δ^{17}O. This uncertainty is based on the long-term measurement of the 4^{th} reference water and does not*

include the homogeneity nor the representativity of the sample (Light stable isotope geochemistry laboratory of Geotop-Uqam)."

SC1-12b. Also, were any samples taken under ice? Ice will fractionate the isotopic composition and make the mass balance different. Has this been accounted for?

Answer: Clarification. We opted to neglect the ice fractionation in the isotopic model, because assumptions concerning the forming (or melting) rate and isotopic signature of the ice would have been needed. To support this assumption, we calculated the isotopic signature of the residual water (i.e., lake water), which is described by:

$$\delta \approx \delta_0 + \epsilon * ln(f_{residual})$$

where δ_0 is the initial water isotopic signature, ϵ is the ice-water isotopic separation factor and fresidual is the residual water fraction.

If the ice thickness is 0.35 m (observed on March 4, 2019) over a surface of $2.79x10^5 m^2$ and the lake volume is $4.7x10^6 m^3$, the ice volume would be $8.7x10^4 m^3$ and f would be 0.98. Considering an ice-water isotopic separation factor (ϵ) of 3.1 for $\delta^{18}O$ and 19.3 for δ^2H (O'Neil, 1968) and a δ_0 of $-10‰$ for $\delta^{18}O$ and $-71‰$ for δ^2H, the isotopic signature of the residual water (δ) would be $-10.06‰$ for $\delta^{18}O$ and $-71.39‰$ for δ^2H. Such variation falls within the analytical uncertainty (i.e., $\pm 0.1‰$ for $\delta^{18}O$, $\pm 1.0‰$ for δ^2H), as shown in the Fig. 3 submitted with this response. Note that a well-mixed lake is assumed for this calculation.

SC1-12c. It also isn't clear why methods are included for water quality sampling. These data don't appear to have been used in this manuscript, so it simply takes up space. Please remove the methods for chemical sampling and concentrate only on the isotopic measurements.

Answer: Clarification. It was deemed preferable not to discuss the physico-chemical parameters and the major ion data. This decision was made in order to limit the manuscript length. However, we agree that section “5.3 Resilience to surface water pollution” could benefit from an additional discussion concerning the geochemical data. We suggest that the geochemical signature of Lake A is compared to the one of Lake DM, Lake B and regional groundwater (i.e., observed at piezometers upstream of Lake B). Below is the proposed additional figure (Fig. 4 submitted with this response) and interpretation to add to section “4.1 Water fluxes and isotopic framework”:

> *“Water samples were additionally collected at the surface and at various depths within Lake A (n = 23) and at Lake DM (n = 1) during the study period and analyzed for major ions, as detailed in section 3.2. The geochemical facies of Lake A and Lake DM samples are illustrated in Figure 5 by the means of a Piper diagram. Both Lake A and flood-water were found to be Ca-HCO3 types, which is typical for precipitation- and snowmelt-dominated waters (Clark, 2015). The geochemistry of Lake A is relatively constant throughout the year and confirms depth-wise homogeneity. Water samples were also collected for comparison at the surface and depth of Lake B (n = 42) and at observation well Z16 (n = 11), which is upstream of Lake B and, thus, representative of the local groundwater contributing to the latter (Ageos, 2016). The geochemistry of Lake B is significantly distinct from Lake A and appears to be influenced by regional groundwater of Na-Cl water type.”*

Also, we propose to add the following material to section “5.3 Resilience of Lake A to surface water pollution” (at L509):

> *“Considering the Ca-HCO3 water type of Lake A (see section 4.1) and the importance of the flood-water inputs to the annual lake water budget (see*

sections 5.1 and 5.2), the flood-water contribution is likely to dampen intra-annual geochemical variations at Lake A and is controlling the low-mineralization levels compared to the neighboring lake (i.e., Lake B). If a reduction in the flood-water inputs was to occur, the geochemistry of Lake A could potentially shift towards that of Lake B. In such a case, an increase of the salinity and in the concentration of Na^{+}, Ca^{2+}, SO_4^{2+} and Cl^{-} would be expected for Lake A.

Note that this issue was also highlighted by Reviewer 2 (see RC2-6a).

SC1-13. Line 170: "The water and stable isotope mass balance of a well-mixed lake can be described. . ." The authors haven't actually demonstrated that the lake is well mixed. A figure showing the lake profiles should be presented.

Answer: Clarification. In a recent study, Arnoux et al. (2017) compared a well-mixed model and a depth-resolved multi-layer model. Both models yielded similar results and provided a general understanding of the groundwater-surface water interactions. The multi-layer model additionally allowed for the determination of groundwater flow with depth, which is beyond the scope of our study.

The advantage of developing well-mixed models lies in their simplicity. Another motivation for the development of a well-mixed model was to be able to compare our results to the Canadian context. In fact, numerous isotopic mass balance models for lakes have been developed across the western provinces (i.e., British-Columbia and Alberta) assuming well-mixed conditions, but only few studies have been carried in the eastern part of the country. Hence, our study is an addition to the actual knowledge in Canada and can be useful in providing data to address pan-Canadian perspectives.

It is worth noting that we developed an isotopic mass balance model assuming well-mixed conditions, but we did take into account the vertical variability of the isotopic signature by fitting the simulated δ_L on the depth-average observed δ_L.

Although this method does not perfectly reproduce the reality, it is nevertheless more accurate than a model calibrated on the observed isotopic composition at the surface of the lake only.

In a recent paper, Gibson et al. (2017) studied the impact of sampling strategies on the water yield estimations for the Turkey Lake (32 m deep) under stratified and well-mixed conditions. They reported 18% difference on the water yield when performing grab sampling (i.e., 1 sample at 1 m depth) and bulk sampling (i.e., assessment of the whole lake water column). The difference was less important (i.e., 11%) when comparing bulk sampling to integrated sampling for epilimnion, metalimnion and hypolimnion. They also reported discrepancies up to 20% for the water yield at the same lake according to the timing of the lake water sampling. This last result shows that temporal shifts may induce more important bias than the uncertainty related to the lake stratification.

Considering the above, we conceive that the developed model yields a valuable estimation of Lake A water balance, because we did consider the lake stratification by using a depth-average isotopic signature to represent δ_L.

Note that the stratification of the lake is also raised in comments SC1-7c, SC1-17, RC1-1b.

SC1-14. Line 198: So, evaporation was held constant for the entire month. Particularly in the spring, that is a brave assumption. This seems to be the coarsest time step. Why was this needed?

Answer: Clarification. In the model, the evaporation is specified at a daily time step. At Line 198, we are referring to the input parameters (i.e,. δ_P, ϵ^+, α^+ and ϵ_K) for the calculation of the atmospheric moisture (δA). In this calculation, the δ_P, ϵ^+, α^+ and ϵ_K are evaporation flux-weighted. Given daily evaporation rate time series, δ_A can only be estimated at a monthly time step. For more details, see Gibson et al. (2015).

SC1-15. Line 208: limiting isotopic composition (Gibson et al., 2015). This is not a common term. Although this can be found in the reference listed, it should be detailed more here.

Answer: Done. Gibson et al. (2015) states that "δ^* is the isotopic composition that a desiccating water body would approach under non-steady-state conditions as it dries up (i.e. $V \rightarrow 0$)."

Line 208 could be corrected to:

> *"...δ^* is the isotopic composition that the lake would approach as $V \rightarrow 0$ (Gibson et al., 2015)."*

However, this concept is referring to a boundary condition (mathematically). It could be more appropriate to define δ^* as: "the limiting isotopic condition (i.e., the boundary condition as $V \rightarrow 0$)".

SC1-16. Line 216: "The above-mentioned equations are computed on a daily time step to calculate the isotopic composition of the lake (dL)." Yet, some parameters have monthly time steps. How do you reconcile that? Does this mean the monthly time steps aren't that important, or should it all be done monthly? This seems like a limitation to the daily time step.

Answer: Clarification. Please see response to comment SC1-14.

SC1-17. Line 218: It has been stated a few times that the lake is well mixed, but this has not been demonstrated with any measurements. The reader needs evidence that the lake is well mixed, particularly over the time period of measurement, which is over the springtime period, when mixing may not be complete.

Answer: Clarification. Please see response to comment SC1-13.

SC1-18. Line 223: "Assuming homogenous hydraulic conductivity of the sediments" This is a big assumption and likely not accurate overall, but in a sandy aquifer, might be a reasonable assumption given other errors in the model. This should be explained more.

Answer: Clarification. Thank you for questioning this point. As you pointed out, this assumption might be a reasonable in the context of this study, but care should be taken when stating so. Your comment made us reanalyze our reasoning leading to this assumption. We did not state the correct hypothesis. In the context of our study, we should simply hypothesize the following:

"The outflow from the lake are roughly proportional to the lake water level."

SC1-19. Line 259 and 263: This is a pet peeve of mine, but "since' is a time word and shouldn't be used to replace "because", please change to "because" everywhere in the manuscript when it is not used as a temporal term.

Answer: Done. Thank you.

SC1-20. Line 269: change to "...lead to overestimation. . .:"

Answer: Done. Thank you.

SC1-21. Line 270, so is the potential underestimation of groundwater exchange underestimated here? Or was something done to account for this. Please explain.

Answer: Clarification. A sensitivity analysis was performed over the evaporative fluxes (E) to address this point specifically (i.e., the overestimation of E, leading to a potential underestimation of the groundwater exchange). When considering E -20%, the model yields to total annual outputs of $1.44x10^7 m^3$, while the reference scenario yields $1.72x10^7 m^3$. This translates to a 16% decrease of the total annual outputs (and inputs). The evaporation represents roughly 2% of the total outputs in both scenarios. The remaining 98% corresponds to the total groundwater and surface water outputs (Q). The partition of groundwater outflow and surface water outflow cannot be determined (see Line 219-220), as their isotopic signatures are conceptually the same (i.e., δ_L). Also, when considering E -20%, the model yields, the surface water inputs (Is) correspond to 68%, which remains very similar to the partition of the reference scenario (i.e., 71%). While E was found to be one of the most stringent parameters, the water balance partition remains similar for both scenarios over an annual basis. Hence, an overestimation of E is misleading.

We could refer the reader to the sensitivity analysis at Line 270.

Does this answer your question? If not, can you please reformulate your question?

SC1-22a. Line 290-295: Why not just measure the GW input? Why does it need to be estimated from the intersection with the LEL?

Answer: Clarification. In hydrogeological contexts where groundwater-surface water interactions are important, the chemistry and isotopic signature of groundwater typically bear some local heterogeneity. Hence, the representativity from a groundwater sample can be hard to understand. In the context of this study, it was preferable to estimate δL from the intersection between the lake's LEL and the LMWL, as it represents the mean isotopic signature of the local groundwater contributing to the lake.

For further details, please see response to comment RC1-2.

SC1-22b. Also, although the evaporation process is the same between flood water and lake water (having the same slope) that is not unusual. What is unusual is that they don't intersect at the same place, so the floodwater is a different source from the recharge from GW or rainfall.

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Answer: Clarification. The flood-water and groundwater have different sources. The flood-water is mainly composed of springtime rainwater and snowmelt water and is originating from a large watershed which extends to the North. The isotopic signature of the flood-water was thus expected to be more depleted relatively to the groundwater (see Line 286-288). The local groundwater is conceptualized as a mixture between local precipitations and flood-water (due to the yearly recurrent flooding of the study area).

SC1-22c. There do appear to be five lake values (one of which appears to be unevaporated floodwater) that fall on the floodwater line, so there is some influence from floodwater on the isotopic composition of the lake. This should be address more fully.

Answer: Clarification. Indeed, some surface water samples from Lake A are plotting near the flood-water LEL and one might hypothesize that this is suggesting an influence of the flood-water on the isotopic composition of the lake. However, of the five Lake A (≤ 2 m depth) water samples that appear to plot near the flood-water LEL, only the most depleted sample was collected during the flooding event in 2017. The other samples were taken in April 2016, June 2016, December 2017 and January 2018. Considering the timing of the sampling dates, these four surface water samples are more likely suggesting mixing between lake water and precipitations.

SC1-23a. Line 331-332: The authors say: "Lake A volume variations are estimated from water level records assuming a constant lake area. When not available, the surface elevation of Lake A is assumed to be equal to the water level at other observation points." I don't understand what this means. Unless this is a pit lake with perfectly straight vertical sides, the Lake area will increase as elevation increases and it will take more water for fill shallower stage heights as the lake gets bigger. Please explain if this is not true for this lake.

Answer: Clarification. The Reviewer is correct. Net water fluxes were calculated considering constant area (i.e., perfectly vertical banks). This assumption was made because of the relatively flat topography (outside of the lake's banks). Attempting to delineate the lake's contour with a Digital Elevation Model (DEM) would have led to unrealistic results. Therefore, we opted to neglect the surface variations. This assumption is not likely to have a significant impact on the model outputs. In fact, the lake water level variations extend over a 2.9 m range only (from 21.87 m.a.s.l. to 24.77 m.a.s.l.), which is relatively small compared to the maximum depth. Hence, the calculated lake volumes are very similar when considering $25°$ slopes or $90°$ slopes over the range of water level variations (see Fig. 5 submitted with this response). However, for the calculation of the isotopic signature of the lake (i.e., δ_L), assuming vertical banks would have led to less representative values. We assumed $25°$ slopes, to calculate a depth-average δ_L. In this case, the lower depths have less impact than the shallower parts of the lake on the estimation of δ_L.

SC1-23b. Furthermore, water levels in a well cannot be used unless there is no GW flow to the lake. If the groundwater level is the same as the lake level, then there will be no flow to the lake and the flow is stagnant. Has this been observed? If not, this GW elevation should not be used as a surrogate for lake level.

Answer: Moot. Please see response to comment SC1-24.

SC1-24. Figure 2 actually show that Lake A water level is at no time equal to Observation well VP, and is generally higher than the well elevation, except in late summer, suggesting the lake is losing water to the well except when precipitation slows down and the lake level lowers. Lake DM, which is a possible surrogate for Lake A elevation, is also never equal to the elevation of well VP, except on the rising limb of the floodwater. Therefore, the well VP elevation is not a good surrogate for lake A elevation and should not be used as such, unless a better explanation can be given.

Answer: Moot. The Reviewer is correct, there is groundwater flow between Lake A and VP. We know that the pumping wells induce a hydraulic gradient, which forces

Lake A water to infiltrate the sandy bank (year-round). However, the isotopic composition of the lake δL is iteratively solved at each time step and is dependent on f, which is the remaining fraction of lake water. The model is thus based on the water level difference between two time steps (not the absolute water level). From August to November, the daily water level variations at VP are expected to be of the same range as the ones of Lake A. Moreover, the water level of VP is a better approximation than Lake DM during the period of no hydraulic connection (i.e., from August to November). Considering the above, the observed water level at VP can be used as a surrogate for Lake A from August to November 2017.

This issue was also addressed in response to comment RC1-8.

SC1-25. Line 338-340: This also a time of groundwater input (at least following the Lake DM elevation compared to Well VP). Is this considered in the fluxes?

Answer: Clarification. At Line 338-340, we refer to the net water fluxes, which include all inputs and outputs. During the flood period (i.e., February 23, 2017 to May 8, 2017), the high water level at Lake A was very likely to impose a hydraulic gradient towards the aquifer, which led to very limited contribution of groundwater to the lake's water balance in comparison to the floodwater inputs (from Lake DM). Hence, we developed the water balance model assuming that the groundwater inputs were null during the flooding period. Contrastingly, surface water inputs were neglected for the rest of the simulated period, while groundwater inputs were expected to play a major role in the water balance partition.

SC1-26. Line 359: So, here the vertical profiles are volume-weighted, which suggests the sides of the lake are not vertical, if they were then you wouldn't need to volume-weight them. But above you say you use a constant lake area to get the volume. Which is it?

Answer: Clarification. Please see response to comment SC1-23a.

SC1-27a. Line 382-384: you do have 3 vertical profiles; you could have at least estimated how big a difference using a stratified model using some max and min values for the isotopes.

Answer: Clarification. The development of a multi-layer model was beyond the scope of this study (see response to comment SC1-17). Although our model is a simplification of the reality, it provides a reasonable estimation of the water balance partition of Lake A and allows to discuss the impact of future changes.

SC1-27b. It also isn't clear from the discussion above this if the direction of groundwater low, in or out of the lake is considered, as the water level data suggests in changes through the modeling period.

Answer: Clarification. Please see comment SC1-25.

SC1-28a. Table 2: A small point, but I'm not sure why commas are used in this table. Scientific notation usually uses a period even for large numbers. Europeans use commas for decimals and then periods for large numbers, so I'm not sure what style is being used here. I would prefer these to all be periods not commas.

Answer: Done. Indeed, all the commas are to be replaced by periods.

SC1-28b. A larger point for this table is that the sensitivity analysis doesn't appear to use very wide values to check how sensitive the variables are. A change of 0.5 per mil for oxygen is not that far outside the error of the measurement. It looks like most of the differences looked at are between 10 and 20 percent. Is that reasonable, what is the variability of the rainfall amounts over time. Granted E isn't likely to have a large range, but some of the variable could have larger ranges than are estimated here.

Answer: Clarification. Sensitivity analysis aims at identifying the input parameters that most affect the robustness of a model and can help in the model parameterization, calibration, optimization, and uncertainty quantification (Song et al.,

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2015). Depending on the complexity of the hydrological model and the authors' objectives, different methods can be employed. In this study, a one-at-a-time (OAT) sensitivity analysis was performed to grasp the relative impact of the input parameter's uncertainties on the model outputs. In order words, our objective was to assess the reliability of the model outputs against a range of possible input values. As the model outputs remained comparable to the reference scenario, we concluded that the model was representative of the local hydrological processes. The selected range of input variables was carefully chosen. Concerning the isotopic framework, a change of $\pm 0.5‰$ for $\delta^{18}O$ was considered adequate to depict the potential bias introduced by sampling and analytical methods. Note that the overall analytical uncertainty (1σ) is $\pm 0.1‰$ for $\delta^{18}O$. For the meteorological parameters, a range of $\pm 10\%$ was selected to represent the potential spatial variability (not temporal variability), as the data was retrieved from off-site meteorological stations. Furthermore, a range of $\pm 20\%$ for the evaporative fluxes (E) was deemed necessary because it was calculated from a selected evaporation model (i.e., Penman-48 equation), which is dependent on numerous meteorological parameters. A comparison with two other evaporation models (i.e., Linacre-OW and open-water simplified version of Penman-48) revealed adequation between the estimations from April to August, but discrepancies during late summer and autumn (see Line 250-258).

SC1-29. Line 414: What about groundwater influx at this time? Ok, I see discussed in the next section.

Answer: Done. Ok.

SC1-30. Line 440: Table 3 provides the relative importance of the hydrological processes for that year that was measured, not for an annual timescale. Measurements for all parameters weren't done for the whole year as well. This should be modified.

Answer: Done. Thank you.

SC1-31. Line 485: tG the mean flushing time by groundwater isn't included in equation 13 and is instead written as tf, which I assume is the time of flushing (by groundwater). This needs to either be explained better, if I don't understand this, or the notation needs to be corrected. Everywhere else it is tf.

Answer: Done. Indeed, it needs to be corrected to tf (the mean flushing time by groundwater).

SC1-32. Figure 9. The caption also has reference to tG is this a different variable or is it tf?

Answer: Done. It is t_f. Thank you for pointing that out.

SC1-33a. The climate change part of this paper is somewhat of a throw away suggestion. There is really no data or simulations that support either conclusion and the modeling doesn't appear to help either. Given the possibility of either more or less flooding the conclusions seem pretty obvious.

Answer: Done. We propose to add the following material at L500: "Considering the above, it is possible to speculate about the potential future impacts of climate change on Lake A."

Additionally, it is possible to add a discussion concerning the impact of the flood-water inputs on the geochemistry of Lake A (see response to comment SC1-12c).

SC1-33b. While the model and the system are relatively well characterized it isn't clear what this gives other scientists other than a look at a local system. How can this be used in other lake systems and can a lake with fewer measurements or larger area or volume be characterized using this model? It would be good if some bigger questions were answered rather than just the local questions that have no real interest to scientists or the public outside of the area.

Answer: Done and clarifications. First, we are grateful to Reviewer 2 for this valuable comment. First, the following material could be added to the introduction at L43 to better highlight the broad relevant of such study:

> *"Knowledge concerning the surface water-groundwater interactions in flooded environments are of global importance, as there is an increasing interest worldwide for undamming rivers and floodplain restoration as management tools for flood risk and/or enhancing ecosystem services (Dixon et al., 2016)."*

Another original aspect of our study is related to the approach, i.e., the use of isotopic tools to cope with the impossibility (or difficulty) to perform direct measurements of surficial water fluxes. The following material could be added to the introduction at L51:

> *"Furthermore, most isotopic mass balance models are applied to contexts where there are no surface water inputs and/or the surface water inputs are quantified by direct measurements (i.e., river stage). However, in floodplains, direct measurement of surface water inflow is difficult (or nearly impossible), while isotopic mass balance models can be useful in providing estimation of the water balance partition with a minimum sampling and monitoring effort."*

Concerning the applicability of the method to other environments, please see response to RC2-2.

Besides, we think it is relevant to add the following material to the introduction at L58 to better explain the outcomes of this study:

> *"The study period spanned a 100-year flood, an event which may no longer occur on dammed rivers (Bednarek, 2001). The present case study is thus*

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a precursor to future research on the impact of restoring the river corridors, as it provides an example of the importance of flood-water inputs on the water balance of a lake in an urban area and during a 100-year flood. This study also provides insights on the usefulness of isotopic data from lakes to complement the hydrogeomorphic methodology for the delineation of the flooding space of rivers. This concept is an important aspect of the recently developed methodology for determining the freedom space for river by Biron et al. (2014) and which was proven to be an economically viable river management approach (Buffin-Bélanger et al., 2015)."

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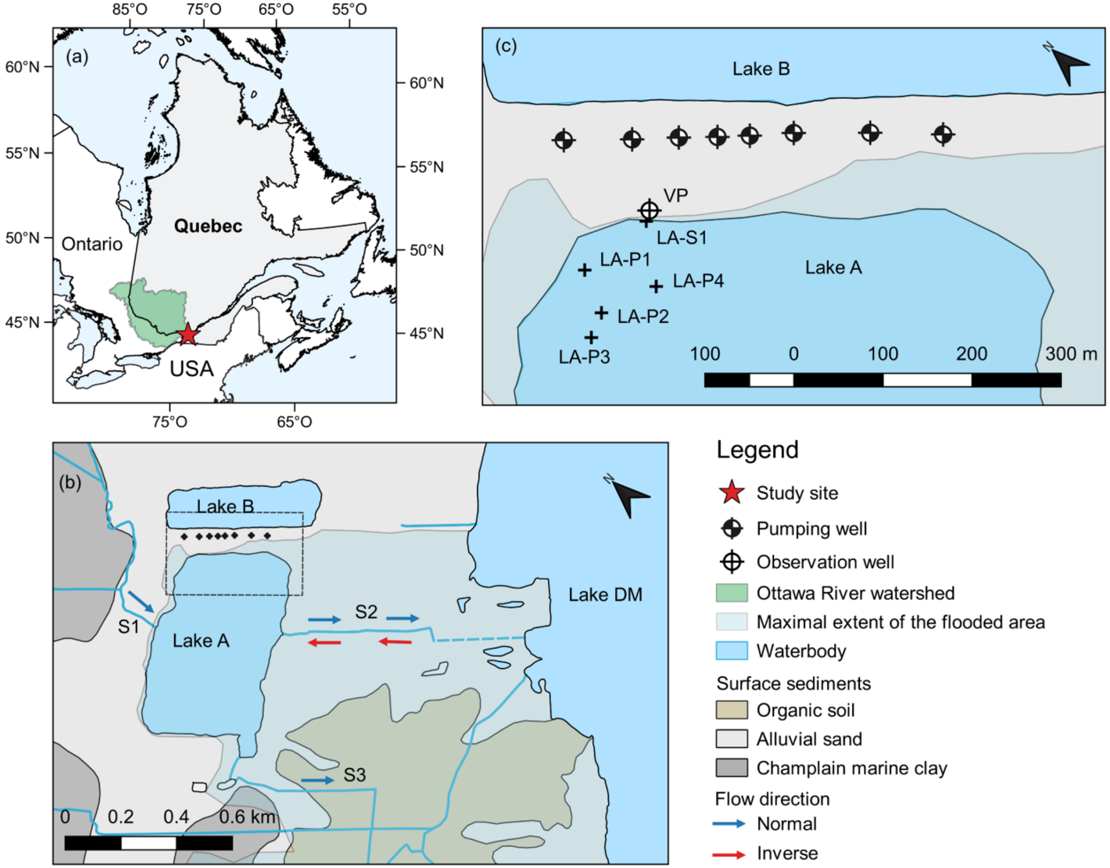

Fig. 1. Revised version of Figure 1.

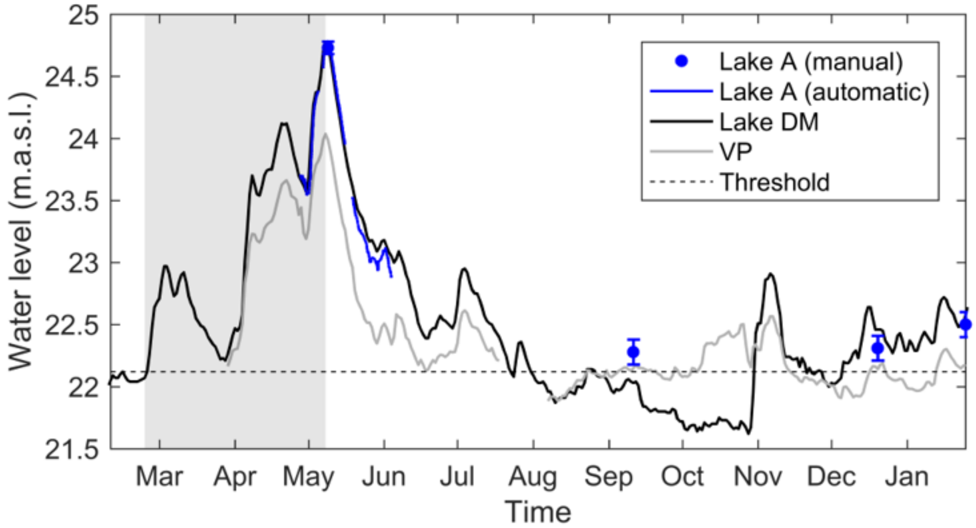

Fig. 2. Revised version of Figure 2.

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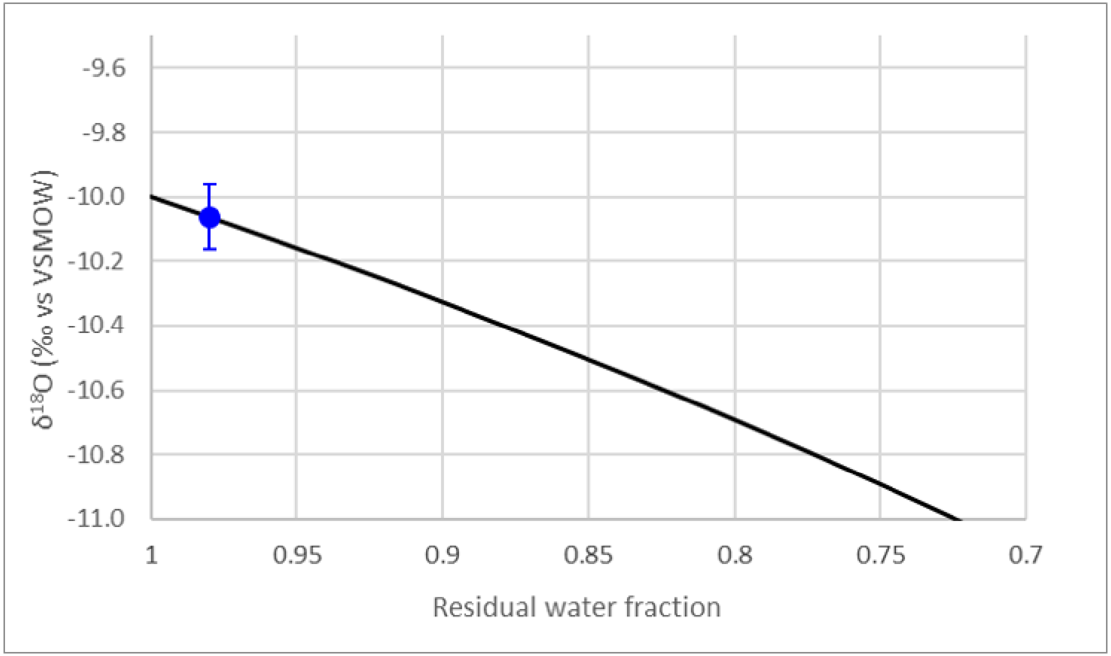

Fig. 3. Isotopic fractionnation due to ice-forming in a lake (solid black line) and the theoretical isotopic signature of the residual water in Lake A (blue circle).

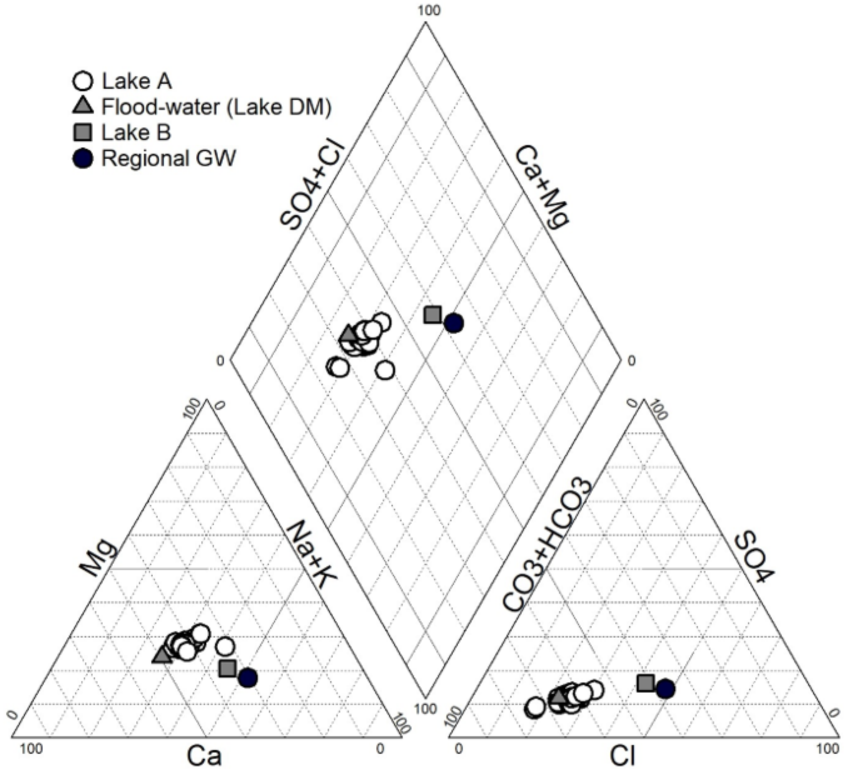

Fig. 4. Geochemical signature of Lake A, Lake B, flood-water and the regional groundwater (GW).

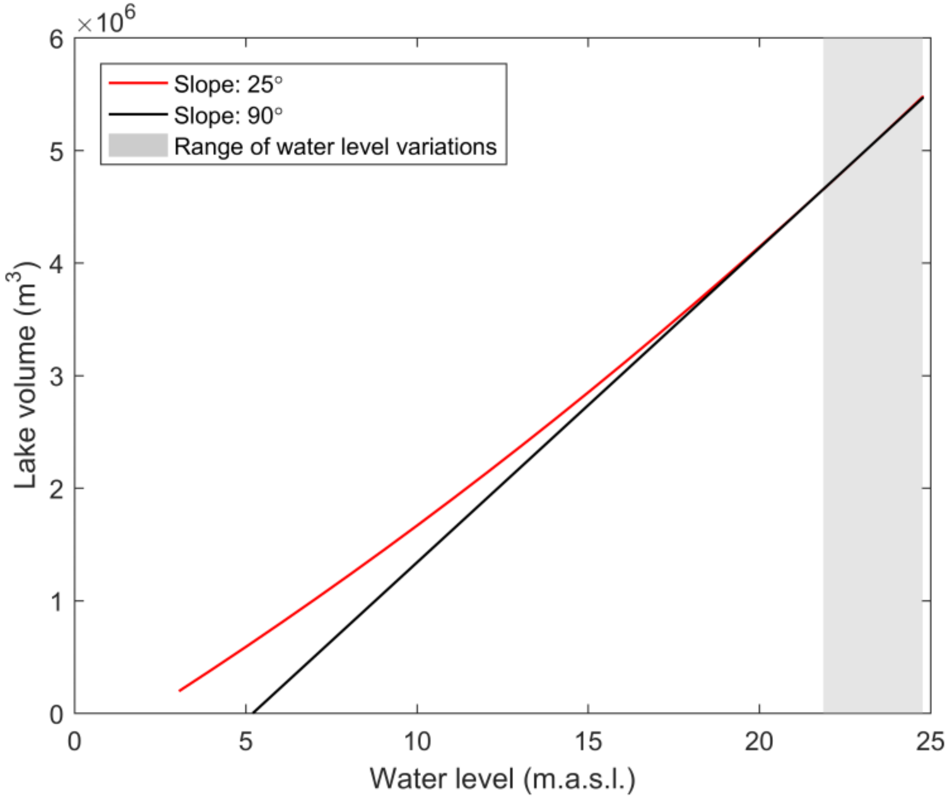

Fig. 5. Relationship between the lake volume and the lake water level for bank slopes of 25 degree and 90 degree.

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