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Biogeosciences Discussions

Interactive comment on "Annual follow-up of carbon dioxide and methane diffusive emissions from two boreal reservoirs and nearby lakes in Québec, Canada" *by* M. Demarty et al.

M. Demarty et al.

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Hi These are aour response to Referee # 1's comments (between "quotes"). We hope this will meet the referee requirements. Sincerely, Maud Demarty

"General comments" "This study provides robust and useful results for greenhouse gases studies and assessment in reservoirs, supported by a substantial amount of data. This manuscript is therefore publishable but I do have several concerns that induce a revision of the paper." "Results from the second reservoir and lakes (Robert-Bourassa and . . .) are scarce (not GHG profiles for instance) and not enough treated in the study. The authors must give more information or results on these reservoirs or

limit the study to the first reservoir."

We agree with the reviewer that this study is supported by a large amount of data and it should be published. Eastmain 1 reservoir is more documented that La Grande 2 reservoir. In accordance with the reviewer recommendation, we focused on Eastmain 1 reservoir in this study and we have modified the text accordingly.

"The aim of the study was to compare emissions from reservoirs to the emissions of nearby lakes. The idea is of interest but the authors must demonstrate that systems were equivalent and that they could be compared. For instance, the age of the reservoir is not the only criterion if the authors compared gross emissions. Mean depth and residence time must be assessed or discussed."

Results from other studies in the area have demonstrated that GHG emissions are not to mean depth or residence time. All parameters describing a lake (water quality, nutrients, plankton and zooplankton, fish population) indicate that a boreal reservoir behaves like a lake within a period of 10 years. It is therefore adequate to compare gross GHG emission between this systems.

"CH4 emissions are highly variable and depends on many factors. The authors may add a chapter in the discussion about high surface values in their study. " The text has been modified to address this aspect.

"The authors must precise in the title and in the methodology that GHG results are gross emissions." The text has been modified accordingly.

"The averaging of parameters (temperature, DO) between stations for a given depth may be misleading and can only be made if the differences between stations are small. This point must be discussed." The text has been modified to address this aspect.

"The authors state several time that the increase of GHG concentration with depth is a result of the accumulation under the ice cover. However, such features are commonly observed in tropical lake with no ice. The evidence for an accumulation under ice

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is mostly the increase in GHG pressure in surface water after the ice start to cover the reservoir." We disagree with the reviewer for this aspect. We have not observed any difference in GHG pressure in surface water. GHG are produce at the water-sediment interface and migrate slowly in the water column. During ice cover, there is an accumulation of CO2 under the ice as the water is no longer mixed with wind and waves action. Similar pattern can be observed in warmer water as a thermocline is present and act as a physical barrier to mix surface and deep water.

"Details comments Abstract Line 2: Robert-Bourassa follow up was conducted only on 2006 and not from 2006 to 2008 as mentioned. " This sentence has been removed as the new version of the manuscript focus on Eastmain 1 reservoir.

"Line 11: One important finding was CH4 no under ice accumulation. That must appear in the abstract." This has been added to the abstract.

"Introduction Page 5430 Line 18: could be add the 2 main processes (emissions and storage)" This has been corrected in the new version of the manuscript.

"Line 25: replace "freshwater" by lakes or reservoirs. Freshwater is a generic term for all aquatic systems." In the manuscript, we will used "lakes" because of the references cited in the text.

"Page 5431:Line 2: Delete "for some time" Replaced by "In the nineties,

"Line 6: first time that GHG appeared in the text. Replace by "Greenhouse gas (GHG)". This has been modified.

"Line 11: Delete "hydroelectric" as all man made reservoirs had the same pathways." This has been modified.

"Line 16: Avoid terms like "Generally speaking, It was not surprising, In fact. . .", please check all the manuscript." The entire text was verified and modified accordingly.

"Line 19: Delete "This statement may be revised in the future according to preliminary

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studies on degassing". This not published data and brings no useful information to the study." This has been modified.

"Line 29: the authors must indicate what are the gases (CO2 and CH4 ?). If CH4 is known to accumulate under ice, that must be discussed as the results of the study were different." In fact CO2 and CH4 can accumulate under certain conditions. In the text, we now refer to Kortelainen et al, 2000. who showed a relationship between CH4 accumulation and oxygen saturation.

"Page 5432:Line 8: point (3) this is an evaluation of the annual gross GHG diffusive fluxes." The text has been modified.

"Line 12-14. This is an important point of the study and the authors must give more information on that issue (see general comments). For instance, Eastmain reservoir is only 5 years old. How the authors could justify this ?" The explanation has been added in the discussion.

"Methodology:Line 26: It will be better to find another reference (study, report. . .)." Another reference has been given.

"Page 5433:Line 5: please give more information on the limitation of stations due to weather conditions (for instance what are the station eliminated from the monitoring. . .) as well as information on the localisation of the stations." More details on localisation of the station.

"Line 8: If I understand well, there was no water quality profiles on the 3 other lakes ? please clearly indicate this." The text has been modified to reflect that water quality was not measured in the 3 lakes.

"Line 14: Explain what do you mean by "mean". It is on an annual, seasonal basis or only for the replicates? see the general comments" For each field campaigns, results from same sampling depth have been averaged (different sampling station thus considered as replicates at the reservoir/lake scale). The text has been modified to reflect

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this.

“Line 17: Explain how the station and depth were chosen.” More details on the choice of sampling station was added to the text to clarify this aspect.

“Page 5434:Line 17: remove “degrees” The text has been modified.

“Page 5435:Line 8: flux can be calculated by directly using the partial pressure, see Guérin et al., Journal of Marine Systems 66 (2007) 161–172 for instance. Remove this sentence.” We used :“According to MacIntyre et al., 2005” to precise our method.

“Line 17: remove“degrees”” The text has been modified.

"Page 5436 :Line 3: unit of t, also try to be consistent: so far temperature was expressed with T (capital letter)” The text has been modified and we have verified all the manuscript to be make sure the unit were consistent throughout the manuscript.

“Line 8-9: remove: “. . . basis using. . .16.04276 g.mol-1)” The text has been modified.

“Results Page 5436 Line 20: is the difference significant?? p value ??” We have added the Anova $p<0.05$ value to clarify the text.

“Page 5437:Line 4: Idem, indicate the statistical test that was used. “ We have added the Anova $p>0.05$ value to clarify the text.

“Line 19: should be Fig 3f and h? Also rewrite this figure caption, it is no clear (reservoirs, lakes. . .) “ This has been done to clarify the figure caption.

“Lines 22 to the end of the paragraph: a long discussion for only one measurement! This paragraph on Mistumis Lake is before the paragraph of the Eastmain 1 reservoir while it was the contrary for CO2 (previous paragraph). Be consistent.” This has been modified for consistency.

“Page 5438: Line 4: It does not seems to have any gradient of dissolved oxygen in the study lakes and reservoirs. Please, check the results or change the sentence.” The

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sentence has been deleted since it was a generality. In fact there is no gradient in the present study.

“Line 13-15: It should be of interest for the reader to have more information on these stations. Where were they located? what were the total surfaces of the reservoir presenting such depths ? etc. . . Also try to modify the text to clarify.” The ancillary available information (e.g. sampling station location , type of flooded land) do not allow to explain the origin of the high pCH4 observed at these stations. Total surface of the reservoir presenting such depths is not available. The text has however been modified to clarify this aspect.

“Page 5439:Line 1 to 6: the chapter must appear in the discussion and not in the result section. “ Taking this comment into consideration, the new version of the manuscript has a new structure.

“Page 5440:Line 7: is a linear increase justified? Maybe once the CO2 concentration reaches a too high value, the accumulation starts to slow down ?? Add a reference if available (?)” Taking this comment into consideration, the new version of the manuscript has a new structure.

“Line 21: the figure 5 is clear and should be called in the previous paragraph to also explain how you interpolate GHG surface concentration during the ice cover period.”The text has been modified.

“Page 5441 Line 1-3. I expect to have the main results and not only methodology in this section.” Taking this comment into consideration, the new version of the manuscript has a new structure.

“Discussion Line 19: precise for CO2.” The text has been modified.

“Line 20: the authors must give more information on that statement and why using gas concentrations lead to an overestimation of the annual diffusive fluxes.” The sentence has been reformulated to better illustrate the concept. Also reference is med to figure

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5 which has been improved accordingly.

“Page 5443 Line 24: reference should be (Tremblay et al., 2009).” This reference has been changed.

“Page 5444 Line 7-21: See general comments. The authors must discuss their results on high CH4 concentration in some part or the reservoir. How could it be explain and the authors must assess the amount of CH4 regarding the morphology of the reservoir.” This has been done.

“Table 1: title: replace site by sites. The authors may also indicate the residence time.” Site changed by Sites. The residence time of the studied lakes is unknown. In this area, water residence time in lake are usually in the order of 2-3 years.

“Table 2: the sampling period could be replace by the season or “ice free/ ice” period to be consistent with the text and other figures. . . The authors must indicate if the number of sampling was for water quality and GHG measurement or not.” To clarify the Table, the mention ice/ice free has been added in a separate column and the number of sampling refer to GHG stations.

“Table 3: Please indicate the number of replicates.” The number of replicate correspond to the number of sampling stations presented on table 2. To clarify the table, this information has been added in the table’s title.

“Table 4: check the title as there was not only the results for 2 lakes ! I would like to have a maximum and minimum potential pCO2 reached (15 May) as the measurements present high standard deviation.” Maximum and minimum potential pCO2 reached has been added.

“Figure 3: The figures were too small to read correctly the results.I wonder why there were only the results for one reservoir and one lake ? Please give information. I cannot see any dashed and dotted lines on the graph. Rewrite the figure caption to indicate which plot correspond to which system for CO2 and CH4. Why the scale for pCH4 (fig

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3h) is so large ??" These errors are corrected.

"Figure 4: Duncan lake is missing on the graph. Can you explain why?" In order to clarify the article, this part of the article has been removed. However, there was no measurable CO2 accumulation under ice at Duncan Lake (student test). Accordingly, in this lake, spring emissions are expected to be similar to summer emissions. The goal of this article being to estimate the relative importance of spring emission in the annual budget of systems accumulating GHG under ice cover, the calculation has not been done for Duncan Lake.

Summary Line 1: please delete "exhaustive" as it could not be reach. The text has been modified. References Houghton et al., was 2001 and not 2007 in the text page 5431. The text has been modified.

Thank you for your attention.

Interactive comment on Biogeosciences Discuss., 7, 5429, 2010.