RESPONSE TO REVIEWER 1

➔ General comments:

❐ This is an interesting study on an important topic and for an understudied set of ecosystems (tropical reservoirs). I was impressed by the efforts at taking and analyzing more than a hundred sediment cores for a single reservoir and applaud authors for such a system focused analysis – there is still too few comprehensive studies based in a single system. I, however, also have some reservations that preclude immediate positive recommendation: first I was confused by your method description, particularly your estimate of sediment accumulation rates and your interpolations. This needs to be clarified.

Response: Thank you for the positive comments and for pointing out the need for more detailed information on our methods section. We carefully revised the "Data analysis" section, adding more information especially about sediment accumulation and organic carbon burial calculations (where we added equations), and about interpolation.

$$Sediment\ accumulation\ rate = \frac{\text{sediment thickness}}{\text{reservoir age}}$$

$$Organic\ carbon\ burial\ rate\ = \frac{\text{Organic carbon mass in the post} - \text{flooding sediment}}{\text{core area} * \text{reservoir age}}$$

❐ Along the same lines, I understand the need for fast publication but this dataset requires/deserves some more consideration – you mention pre and post--- flooding intervals but there is little mention on this in the discussion. You basically focus your entire discussion on comparison to previously published data with many detailed

numbers provided – I do not think this necessary. The ms would be much stronger if you would make a clear case that large inputs from a highly productive forest produce large C burial and CH4 emissions. Massive CH4 production and emission in sediments supplied with lots of OM and particularly in hot tropical conditions is a stand---alone argument. This is also, as far as I see, not so much an oxygen/stratification driven effect but rather effect of high productivity – which is, in fact, interactive. You do not need to compare your findings to those from many other reservoirs and if you decide to do so, focus rather on processes and ratios than on absolute numbers.

Response: We appreciate and fully agree with this comment. We carefully revised the manuscript reducing the unnecessary comparisons with other studies and focusing more on our results. Based especially on this comment, we decided to split the Results and Discussion section in the revised manuscript. The discussion is now more straightforward and, thus, easier to follow. As suggested, the comparisons with other studies are now focusing rather on the processes occurring in other biomes. We also extended the discussion about the especially high productivity combined with the high temperatures of the Amazonian biome.

❒ **The manuscript is well written but some sentences are a bit too complex and should be re---written. I suggest that the entire text would benefit from a careful editing (I spotted some minor typos) and streamlining.**

Response: We revised the entire manuscript, and we are confident that the text has been improved.

➔ **Specific comments: Introduction**

❒ ***However, most of the CH4 is emitted from reservoirs via ebullition (i.e., gas bubbles), which is very difficult to measure due to its strong variability in space and time (McGinnis et al., 2006; 20 Deemer et al., 2016).*** **This is a very generous statement about ebullitive fluxes but nor necessarily correct. Some compact sediment do not allow for large bubble accumulation despite high methane concentrations. Ebullition is not always major emission pathway. Please re-phrase this sentence.**

Response: While there is evidence that ebullition indeed is the major CH_4 emission pathway in many reservoirs (Deemer et al. 2016 Bioscience), we agree that we should be more balanced in this statement. We changed this sentence, which now reads: "*However, in many reservoirs, CH4 ebullition (i.e., gas bubbles) is an important or dominant emission pathway, but it is very difficult to measure due to its strong variability in space and time (McGinnis et al., 2006; Deemer et al., 2016).*"

➔ **Methods:**

❒ ***Measurements with a multiparameter sonde (YSI 6600 V2)… showed that the relatively shallow water column (mean depth: 6 m) is generally well mixed.*** **I am not sure whether YSI profiles can give you a good measure of stratification/mixing and besides this is a discussion already. Please state you results and revise the text.**

Response: We understand your concern but we are confident that our YSI profiles can accurately indicate the lack of stratification during our samplings. The water column profiles of dissolved oxygen and temperature show that there are no big differences between surface and bottom waters, and thus that the water column is not strongly stratified for any extended period of time. This is important information related to CH_4 production. We therefore now include all the raw data in the supplementary information (total of 28 depth profiles spread along the reservoir during the two field campaigns), moved this sentence from the Methods to the Results, and rephrased it: instead of speaking of a well-mixed water column, we now say that the water column profiles indicate a lack of stable stratification over any extended periods of time. It is also worth to mention that our sonde was calibrated before each fieldwork and we thus have confidence in the measurements.

❒ ***In each of these cores, the first and second layer (0 to 4 cm deep), the last sediment layer above the pre---flooding soil surface, and about one sample every 8 cm in between were analyzed.*** **Why these intervals? Briefly explain or clarify sampling design.**

Response: Due to limited time and resources for chemical analysis, and since the OC content of sediment is prone to decrease during microbial degradation, we chose to analyze representative samples of the fresh material (surface sediment layers) and old material (bottom sediment layer), as well as some layers of intermediate age. From these measurements, the OC content of the non-measured layers was linearly interpolated from the measurements. Similar approaches have been used in previous studies, e.g. Mendonça et al. 2014.

We changed this part of the text in the manuscript for: "*OC and total nitrogen (TN) concentrations were determined in the 19 cores, which were distributed across the reservoir area. In each of these cores, the first and second layers (0 to 4 cm deep, containing the fresher OC), the last sediment layer above the pre-flooding soil surface (containing the older OC) and one sample every ~8 cm in between (OC of intermediate age) were analyzed.*"

❒ ***Using a core liner with side ports, 2 ml of sediment were collected using a syringe with a cut---off tip, added to a glass vial with 5 ml of distilled water, and closed with a 10 mm thick butyl rubber stopper.*** **We use similar method to evaluate sedimentary CH4 but samples are killed with concentrated NaOH solution, how does it work with DI water?**

Response: We used distilled water because there was no need for sample preservation. Instead, we equilibrated the slurry (2 mL sediment + 10 mL distilled water + 13 mL headspace of ambient air) immediately after sampling by vigorously shaking the 25 mL glass vial, and then transferred the gas phase to syringes immediately on the boat. The gas phase was stored in the syringe, closed with a gas-tight valve, and we injected the gas into the analyzer within the same day. We revised the manuscript text accordingly in order to clarify.

❒ ***The CH4 concentration in pore water was measured by an Ultraportable Greenhouse Gas Analyzer (UGGA, Los Gatos Research) with a custom---made sample injection port, and the peaks were integrated using an R script.*** **I believe that what you want to say here is that headspace concentrations of CH4 were measured with UGGA and the re---calculated to pore---water concentrations**

Response: Yes, exactly. We rephrased the sentence as follow: "*The headspace CH_4 concentration was measured by an Ultraportable Greenhouse Gas Analyzer (UGGA, Los Gatos Research) with a custom-made sample injection port, and the peaks were integrated using R software (RStudio Version 1.1.383). The CH_4 concentration in the pore water was calculated from the headspace CH_4 concentration, based on the Henri's law constants.*"

❒ ***Assuming that a CH4 concentration >80% of saturation concentration is indicative of a sediment layer prone to contain a gas bubble; this assumption mirrors the potential loss of gas from the sediment during coring and sampling.*** **Any literature to support this?**

Response: We wanted to account for the expected loss of bubbles during coring and sampling, and chose 80% saturation as an arbitrary threshold, because we could not find any literature on the quantitative loss of gas bubbles during gravity coring and sampling. However, as the 80% threshold was a concern of both reviewers, we chose to use 100% saturation instead; the difference in the number of oversaturated layers was very similar between the 80% and 100% threshold anyway (22 and 20 sites of 25, respectively). Importantly, given that our method certainly underestimates bubble (and thus CH_4) content of the sediment, our conclusions regarding the potential for CH_4 ebullition are conservative. We revised the text accordingly.

❒ ***The average sediment accumulation rate (SAR; cm yr---1) was obtained by the ratio of post---flooding sediment thickness and the reservoir age.*** **Same here. Do you have any support for this method to estimate sediment accumulation rate? What about movement of sediments or turbidities? Do you have a photo of your sediment cores? Did you try to date them?**

Response: The approach we used to estimate sediment accumulation rate was used, for example, in the studies by Renwick et al. 2005, Kunz et al. 2011, Mendonça et al. 2014 and Quadra et al. 2019. These references were added to the manuscript. This approach considers that the layer of transition between pre- and post-flooding sediment corresponds to the year when the dam was closed and the reservoir was flooded. This moment is the onset of a lacustrine depositional regime, which is characterized by different sediment texture and composition in relation to the pre-flooding soil or fluvial sediment. Therefore, this transition layer is easily identified visually. We added photos of the core aspect to figure S2, where we show that the transition is clear (see below). The approach we used considers only two dates

– the year of reservoir flooding (the bottom of the post-flooding sediment) and the year of sampling (top sediment layer). Therefore, the sediment accumulation rate we estimate from sediment thickness (cm) and reservoir age (yr) represents an average over the reservoir lifetime. This average, thus, includes any temporal variability in sediment deposition caused, for example, by change in sediment load or internal sediment movement. As we sampled a large amount of cores distributed along the reservoir body, we assume that we captured, the best way possible, the spatial variability in sediment deposition due to sediment focusing (sediment movement with preferential deposition in deeper areas).

We did not use radioisotopes (e.g. 210Pb) for dating, since also these methods suffer from uncertainties, rely on the choice of model for interpretation of activity profiles, and are affected by sediment mixing. Another very commonly used radioisotope, 137Cs, is very similar to the method used by us, because it considers the difference between years to calculate average sediment accumulation between these dates (in the case of 137Cs, between the Chernobyl accident 1986 or the peak of atmospheric nuclear weapon testing 1963, and the year of coring). For these reasons, we argue that our method does not produce less reliable data than other methods.

<u>New References:</u>

Renwick WH, et al. (2005) The role of impoundments in the sediment budget of the conterminous United States. Geomorphology, 71(1-2), 99-111.

Quadra GR, et al. (2019) Environmental Risk of Metal Contamination in Sediments of Tropical Reservoirs. Bulletin of Environmental Contamination and Toxicology, 1-10.

Figure S2. Pictures with sediment cores of Curuá-Una reservoir showing the transition zone between pre-flooded (gray color) and post-flooding (brown color) sediment.

❒ ***SAR was positively correlated to OC burial rate in the sites.* Isn't this implicit from the method you used to calculate SAR and OC burial. You used total OC – which is clearly a function of sediment thickness to calculate burial and then you used thickness directly to calculate SAR? Either I am confusing something or both of these functions use the same dataset.**

Response: While the total OC inventory can be a function of sediment thickness, this does not need to be the case, since different kinds of sediment can have very different OC content; a quite thin but OC-rich sediment (e.g. algae remains) can have the same inventory as a very thick but OC-poor sediment (e.g. sand). In our case, SAR and OC burial strongly correlate, probably because the sediment not very heterogeneous. The regression in the manuscript is to show that, regardless of sediment OC content, OC burial can be predicted from SAR, which can be more easily estimated from visual analysis of the sediment cores, without the need of laboratory analysis of sediment density or OC content.

❐ ***used to estimate the OC burial rate (g C m---2 yr---1) from SAR for the coring sites where OC content was not analyzed.*** **Ok. I am a bot confused here. Please indicate here for how many sites you have the data and how many were treated to this interpolation.**

Response: In the new version of the manuscript, we explained it better adding the details the 'Data analysis' section. We took 114 cores and all of them were analyzed for sediment thickness and SAR. 19 of these 114 cores were also sliced and analyzed for OC content and OC burial rate. From the regression between SAR and OC burial rate, we estimated OC burial for the remaining 95 cores, which were not analyzed for OC content.

➔ Results and Discussion

❐ I think that this section can be much reduced by clearly discussing new findings and possibilities as well as perhaps some more quantitate analysis of inputs, Currently there is too much comparison to previous research and too little insight into the implications of this study. The work is valuable and has a potential for impact but more work in this section is needed.

Response: Thank you for pointing this out, and we agree. We decided to split Results and Discussion section in the revised manuscript, as we believe that this will make the text more clear and easy to follow including a discussion that more coherently concentrates on the new findings. For example, we now only cite previous studies in order to illustrate our findings, not for mere comparison of quantities. Also, the discussion is now organized by findings, and no longer by measured parameter (as it was in the Results and Discussion section of the original submission).

❒ **Figure 3: perhaps a mass balance for sedimentary CH4 would be informative here?**

Response: While a mass balance would be interesting, we are not able to calculate it using our data. To calculate the mass balance, we would need the CH_4 input and output rates, which we cannot estimate from the measured pore water concentrations.