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Biogeosciences Discussions

Interactive comment on "The influence of reservoir traits on carbon dioxide emissions in the Belo Monte hydropower complex, Xingu River, Amazon – Brazil" *by* Kleiton R. Araújo et al.

Anonymous Referee #1

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This paper is about the CO2 concentration and emissions from a newly created hydroelectric reservoir complex in the Amazon area. Given that particularly Amazonian reservoirs have been pointed out as high emitters of greenhouse gases, and since emissions typically are higher the first years after flooding, this study is certainly valuable and interesting. In particular since the new reservoir is a run-of-the-river type, which is supposed to result in lower emissions than storage reservoirs.

The study seems to be well-conducted, based on standard methods. However, the presentation severely lacks focus and clarity. I will give in the following a few ideas on how the paper can be improved, but I really want to urge the senior authors of this

paper to support and help the first author, who is apparently a MSc student and writes his/her first paper (it says in the Acknowledgements). It also takes a thorough revision of English language use and style.

What makes this study interesting is that it studies the Belo Monte hydroelectric complex, a all-new installation in the Amazon (it's not even up at full capacity yet), the biggest in the Amazon so far, and one of the biggest in the world, and one that was heavily disputed and criticized. This is not mentioned at all in the paper! I could imagine that the story could be built around the case of this new and huge installation. New reservoirs typically have elevated emissions, but here apparently biomass was removed before flooding, at least partially. Is this visible in the data? One of the reservoirs is run-of-the-river, does it really have lower emission than the storage reservoir? These questions could be formulated as hypotheses, addressed with the data (i.e. figures should illustrate data in a way that relates to these hypotheses), and then explicitly answered in the Discussion. This would give the study a much-needed 'read thread'.

It will take a thorough rewriting of the manuscript before it may become acceptable, but since it seems to be good data from a understudied site of high interest, I think in the end this could become a valuable addition to Biogeosciences.

Detailed comments: Title: the influence of reservoir traits is not explored to any greater depth. Which traits? I'd suggest to change the title accordingly, maybe "CO2 concentrations and emission in the newly constructed Belo Monte hydropower complex in the Xingu River, Amazonia".

L41. The inland water area number seems wrong. See Verpoorter et al. 2014 GRL.

L42. Only the Raymond study gives a global estimate, the other citations are regional-scale.

L45-54. There's a lot of detail here that is not addressed by this study and could be removed here, e.g. microbial community structure or priming.

L70. While emission are typically high, the lifetime emission of a reservoir is proabably rather a function of the long-term emission level, and the short initial emission pulse may have less influence.

Study Area: This must mention that the installation is new, and it must describe in how far and where vegetation was removed before flooding, and when the flooding took place.

L106 and 114. The water retention times are very short, even for the storage reservoir it's only 1.5 days. Are these numbers correct? If so, these reservoirs, given their size, must be characterized by quite strong water flow, and thus the gas exchange velocity is probably hardly related to wind speed, but rather to water speed.

L112. 97% of the capacity are at the Belo Monte dam, so the ROR dam only produces 3% of the energy even though it contains one third of the number of turbines?

L116. Where is the hypolimnion typically starting? Did you do any depth profiles of T and/or DO? If so, please show and report! If not, please cite a study that states that the thermocline is typically at >20 m.

Section 2.2. It would be more easy to understand if you first described your sampling campaigns, and then tell about any gaps.

L144. Why was 60% of water depth chosen? Seems arbitrary. Also, it would be good to know the actual depth at these sites. A raw data table should be submitted alongside with the paper.

L150. How good was the evacuation? In my experience, it's very difficult to get a good vaccum, but probably 10% or more atmosphere will remain, which may dilute or contaminate your samples. Was this checked?

L154. Start this paragraph with saying "Diffusive CO2 emission was measured with floating chambers". Also, please give the dimensions, shape and type (transparent / opaque) of the chamber.

L161. I guess you mean logging frequency, not time.

L168. Atmospheric pCO2 of 380 ppm seems like an outdated value, or are these your own measurements in air?

L184. This sentence seems unnecessary.

L191. A station is stationary. You probably mean a handheld meter or device?

2.5. Statistics. I did not know Permanova, so this should be better explained. Is it a parametric method? Because it is stated that the data did not follow normal distribution. However, later in this paragraph, you mention some data were normally distributed and used t-test; this is confusing. Also, in the entire paper, report the actual p values, not just if p is lower of higher than 0.05.

Results. In general, this section describes many findings and patterns, but it does so in a quite unstructured way, and is therefore difficult to follow. I really think it would help this paper if only the results were presented that are relevant to the hypotheses or research questions. Also, the language describing the patterns should be improved. For example, it needs to explained what numbers are given (e.g. L208, is this the mean $\pm$ standard deviation, or something else?), and comparisons between two groups describe a difference and not a variation (L208). Also, increase and decrease (e.g. L245 and L249) refer to a change over time and thus some form of time series data, while this study has data for two discrete sampling occasions, and thus can only speak about differences. It should also always be very clear what exactly was compared. For example, in L213, it was unclear what was tested here, the variability in pCO2 within and environment, or between environments?

Again concerning statistics, it is unclear to me how a comparison between two groups can render a R2 value, but maybe that's a part of the Permanova, and should in that case be better explained in the Methods.

L215. Here you speak about spatial variability, but do you mean differences of means

between different environemnts, or the variability of measurements within one environment type?

L219. “Outside reservoir areas” is not a very illuminating term. Could choose another name?

L224. 281 μatm at 60% depth, how much is that in meters? And how can deep water be undersaturated in oxygen? Typically it is oversaturated. Or was this above a macrophyte bed?

L231. Here it says the the data from the two seasons were pooled, but L237-241, the seasonal data are discussed separately. This is confusing.

L246. The seasonal difference in IR was very small, certainly not a “pronounced difference”. Interestingly, FCO2 was very different between seasons in spite of similar pCO2, which indicates a strong variability in k. Was this the case?

L250. What kind of spatial analyses? Comparison of the means for different environments?

L251. “evaluated together”, is this warranted? Were these two groups similar?

L256. “Pasture” is a new and undefined category.

L262. What’s the measure of variability? It seems that in this study, you mostly compared means, but if you want to address the variability, you maybe want to look at relative standard deviations, interquartile ranges or something similar. If you want to stick to comparing means between environments, please formulate this explicitly in the text.

L263. Varied significantly between what?

L266. The 90 km downstream site is so far away it’s not even on the map. I wonder in how far it is relevant to this study at all, or could safely be omitted.

L270-273. Go straight to the results instead of first describing what was not done.

L275. The relationship between k600 and wind speed is very weak. At any wind speed, k can vary with a factor of 2-4. This is quite often the case, and maybe even expected in such system where water moves fast, and thus water turbulence is quite independent of wind speed.

All in all, the Results give many compairosn, What about making matrix tables where you can give test statistics for each comparison?

3.3. Did you ever measure depth profiles? Would be very interesting to show these data, to asses if really the turbine intake is in the epilimnion, and to assess the potential outgassing through turbine passage.

L292. This is not one of your results.

L296. The Discussion should start with your most important finding, not with citing other studies.

L303. This seems to be an important finding. Could you make a figure that illustrates this finding, to make it visible and convincing?

L309-326. This discussion is very hypothetical and not much related to your data.

L327. Not really. In your own data, there is an example of differences in k producting very different emission fluxes in spite of similar pCO2 (see my comment above).

L328-334. This may be the main message of this paper. It would be good if you produced a Figure that illustrates this finding.

L340-341. The Methods need to describe explicitly which areas were flooded with intact biomass, or after biomass harvesting.

L350. Could you actually observe increased water clarity in your data / samplings? If not, this discussion is not helpful to explain your data.

L355. pCO2 were only lower during low water compared to high water in the downstream and dam categories. For flooded and river channel, they were similar (Fig.3). So it is not warranted to speak about a “drastic decrease”.

L375-383. Could the difference between Belo Monte and Petit Saut be explained by different water intake depths? Do you have water profile data?

L391. It seems not warranted to assume that any site or time point should serve as a “reference” for river pCO2, since it varies in time and space.

L395. What is meant by “turbine activity”?

L398-406. I think you could further explore the patterns in k, e.g. between environments, and between reservoirs. Were the values in these resservoirs rather similar to other reservoirs or lakes, or rather to rivers?

L403. There is no strong positive correlation between wind speed and FCO2 in your data. Fig 5 shows weak relationships, at best.

L423-425. This sounds like the main result of this study. Make a figure to show and highlight this result, and discuss it in terms of reservoir properties and operation type.

Figure 3. In panels c and d, I would suggest you order the environments in flow direction. That is, upstream first then XR environments, then IR environemnts, then downstream. If it gets too crowded, make two separate panels for high and low water. And the same for pCO2 and FCO2 and k600, i.e. you may end up in 6 panels instead of 2. Together with panels a and b, it would be 8 panels.

Figure 4. When seeing this figure, I wonder how much of this spatial variability is driven by differences in pCO2, and how much by differences in k.

Table 2. What are the values, mean $\pm$ standard deviation? How many measurements are behind each of these averages? Could you introduce a column with “n”? The k values are high and resemble rather riverine systems than lakes or reservoirs, I guess

an effect of the fast water flow. The comparison with literature values would be better and more visible in a graph than in a table.

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