The manuscript titled "Surface CO_2 Gradients Challenge Conventional CO_2 Emission Quantification in Lentic Water Bodies under Calm Conditions" by Patrick Aurich et al. presents an insightful study on CO_2 dynamics in the near-surface layer of the Bautzen Reservoir. I think the first author is a PhD student, and I would like to extend my congratulations to him, recognizing the complexity and difficulty of this research.

The manuscript benefits from a high temporal and spatial resolution dataset, and the analysis provides valuable insights worthy of publication. However, I think the manuscript requires further development and refinement before it is ready for publication. As I am not concerned with remaining anonymous (and I can't remain anonymous given the nature of my comments ☺), I have attached my detailed feedback in the accompanying PDF document.

I look forward to reviewing the revised version of this manuscript.

Response: Dear Mariana, thank you for the nice words and your suggestions on our manuscript. We are happy that you recognize the value of our study and that you think it is worth publishing in Biogeosciences. Please find our response to your comments below. In a revised version of the manuscript, we will address your suggestions for improvement and adjust the language, spelling, and style according to your feedback.

Detailed comments

Line 14: not defined yet, I assume thin boundary layer. But note that this abbreviation is normally used a thermal boundary layer

Response: Yes, we will add the abbreviation to the previous sentence.

Line 27: I would go a bit further on the implications, what does mean of global carbon cycle?

Response: Thank you for the comment. The implantations for the global carbon cycle are, to this point, unknown. The chances to find the conditions as found in our dataset are rare, however, the magnitude of fluxes speaks for itself. For this abstract, however, we think it is enough to highlight the existence of pronounced CO2 gradients, as this guides researchers in further studies to take the effect into account.

Line 40: You mention before earth surface and atmosphere and you suddenly change to water atmosphere. Also I think water-atmosphere, as we use air-sea

Response: Thank you for this comment. For clarity, we will change it from earth surface to water surface.

Line 55: also the fact that most of these k-parametrization assume a zero-intercept

Response: True. That's why we prefer to use a parametrization by Wanninkhof with a non-zero intercept. This aspect will be added to a revised version of the manuscript.

Line 69: check also Mustaffa et al., 2020 :)

Response: Thank you for your comment. Mustaffa et al 2020 is indeed a very good reference to highlight the global relevance of the effect. We will add the reference.

Line 72: some reader might not know what that is

Response: Thank you for this note. However, we think that the term epilimnion is textbook knowledge for limnologists and does not need further explanation.

Line 74: here you use the -, unify throught the ms

Response: Thank you for your note. You are right, we will unify nomenclature and style in a revised document.

Line 124: what does the flashing?

Line 128: which is the range? And the accuracy/precision of the sensor?

Line 136: How often did you calibrate? how do you correct?

Response: Thank you for those questions. The measurement routine was kept brief to avoid disrupting the reading flow. However, we acknowledge that specific terms should be explained, and therefore, we will revise the description of our methods to provide more detailed explanations. We calibrated the probes before and after deployment and took occasional water samples for GC analysis and quality control. In that sense, we will provide additional detailed explanations in the supplement.

Line 143: How do you transform your 2-m wind to 10-m?

Response: As mentioned above, we will provide more detailed information on the methods in the revised manuscript. However, the parametrization of U10 was done using the wind.scale() function provided in the LakeMetabolizer package in R. That function is based on a logarithmic wind speed profile described by the equation

$$U10 = Wind\ x\ (\frac{10}{height})^{\frac{1}{7}}$$

Line 145: Probably nice to know the "maths" behind the function for GPP and R, for example

Response: Thank you the comment. Explaining all the equations behind the lake metabolism calculations is beyond the scope of our paper. The package LakeMetabolizer, including a GitHub repository with all the functions used, is published in https://doi.org/10.1080/IW-6.4.883. There is also a good review by Peter Staehr about this topic (https://aslopubs.onlinelibrary.wiley.com/doi/10.4319/lom.2010.8.0628).

Line 150: Out of curiosity (and also for paragraph consistency), do you have measurement of oxygen before the mixing, when temperature was 30°C?

Response: Yes, we have oxygen data for that period. Oxygen reached up to 170 % saturation during the stratified period. We think that information is out of the scope of this study and it would disrupt the reading flow and distract from the main topic.

Line 150: The result section needs a bit of re-estructure for clarity. For example, you talk about CO2 during the day in line 159 and again in line 172. I suggest to unify. Same get for other parameters.

Response: Thank you for your comment. We tried to structure the sections by the content. However, we acknowledge your concerns and will revisit the content structure for a later version of the manuscript.

Line 155: add in M&M how this equilibrium is calculated. I guess is the CO2 from atmosphere (?). How did you get it?

Response: Thank you for pointing that out. In fact, the measurement platform was equipped with a CO2 analyzer, which was used to determine EC fluxes too. This is published and cited in our manuscript in

Spank et al. 2020, 2023, and 2024. For the sake of completeness, we will add this to the methods part in the supplement.

Line 155: consistency: in the main text you use Ta and Tw. Also, do you have the temperature at 5cm?

Response: Thank you for pointing this out. We will correct the text in general to be consistent throughout. Regarding the temperature in 5 cm depth – we do not have that. We tried to calculate the surface temperature from outgoing radiation measurements. However, this is an indirect measurement, which, further, can be error prone due to waves etc. We therefore decided to use the temperature measured using the thermistor chain, which we found to be the most robust method.

Figure 1: and at 25 cm?

Response: This is a very good comment. We did have an oxygen probe installed in 25 cm depth, however, the sensor failed to log data. This was very unfortunate for our study, because it could have helped us resolve the oxygen gradient and the metabolic activities at the surface.

Figure 1: the bars are a bit misliding, as sometimes there is a lot of variation. I was wondering if it could make more sense to add a box plot, where you will also show the mean and the range

Response: Thank you for your note. In the process of creating this figure we tried many different designs and found this design to be the best compromise that shows the most important features of our dataset very clearly. Especially the bars helped a lot resolving the diurnal patterns and light dependence of the other parameters.

Line 170: U 10 m or U 2m? Also mentioned in the figure

Response: Its U10. We will uniform the nomenclature in the revised version of the manuscript.

Line 175: which is? needs to be stated in the M&M

Response: Thank you for the comment. As mentioned above, this will be part of the revision of the M&Ms part.

Line 184: I guess the answer is no but do you have measurements of CO2 in the bottom? If not, worth to considered for the next project :)

Response: Thank you the question and tip. We took monthly water samples for GC analysis from different layers – also from the hypolimnion. Those data show CO2 accumulation in the hypolimnion during stratification – a common observation in lakes (e.g. https://bg.copernicus.org/articles/10/7539/2013/bg-10-7539-2013.pdf). However, in this manuscript we focus on the surface layer.

Figure 2: Carefull on using deltaCO2 for two different things: air-water (as in Equation 1) or 5-25 cm. Find another abbreviation of metion all the time deltaCO2_(5-25cm)

Response: Thank you this comment. We did not recognize that before, but will change it for consistency in a revised version of the MS.

Figure 2: This means dots should have a error bars or something that show the variation you are averaging.

Response: Thank you for the comment. We tried different versions of this plot already, including boxplots. Those did not turn out nice and concise. However, adding error bars to the dot is possible and will be considered for the revised version of the manuscript.

Figure 2: See Stolle et al. (2020), figure 13. We presented k but could have also a relationship.

Response: Yes - interesting. It is a common observation that wind speed above lakes is lower in the night. That would mean that the same argumentation (low wind and low wind driven k during the night) applies both to inland water and the sea.

Figure 3: It is always nicer when you can understand the caption and figure without the need to read the paper. Please explain all more precise

Response: Thank you for the comment. We tried keeping the caption short, but we agree with your comment and will make a stand-alone caption in the revised version.

Line 198: careful with the wording, 5 ms-1 is not particularly windy :)

Response: We agree with you – although for a lake we would call 5 m/s rather windy. However, we defined the windy and calm period as mostly windy and mostly calm period, respectively, before. We think this classification is understandable to the reader throughout the manuscript.

Line 205: emission through your study period? We need a time so you can get rid of your time unit.

We are not sure if we understand this comment. We mention the length of our study period here (7 days). We think it is clear that the total emissions given in g/m2 refer to this 7-day period.

Line 207: How relieable are the EC-flux without wind/very low wind speed? You mentioned before they have problems.

Response: The EC data went through a quality control process as referred to and cited in the methods section. Measurements that don't pass the quality control were flagged and withdrawn. Those bad data were excluded and are visible as gaps in the flux plots.

Line 208: The discussion is again very interesting but difficult to read. I suggest to find the main finding of each figure, explaining in the result section and then discussed here. If the journal allow, adding headers sections to the discussion will also help the reader

Response: Thank you for the comment. We agree with you that the discussion can be difficult to read. We already tried to structure it in a way of highlighting the main results and proceed discussing possible causes and interplays. However, we will try to work with sub headers for the discussion section to improve reading flow.

Line 213: in the ocean I measure very low CO2 concentrations but never 0. Is this actually possible/documented? Is like CO2 anoxia?

Response: This is an interesting thought. Due to the carbonate buffering system and CO2 uptake by phytoplankton, very< low CO2 can often be observed in hyper-eutrophic lakes. We do not have pH data

from this study period, but in previous works we observed pH values up to 11. For theoretical reasons CO_2 is not zero at this pH, but extremely low. For water-atmosphere diffusion it does not make a big difference whether CO2 is zero or close to zero. For planktonic organisms this is no issue since they rely on bicarbonate. Interestingly, the point of low CO_2 concentration is relevant in extremely acidic waters. There, all TIC is present in form of CO2. That means that photosynthetic algae can get carbon limited in such lakes (https://link.springer.com/article/10.1023/A:1005165615804)

Line 229: I think it is not defined: is like the mixed layer detph in oceanography?

Response: Thank you for pointing this out. The photo-active layer, also know as euphotic zone, is generally the layer where photosynthesis dominates metabolic processes. It is defined as the part of the mixed layer in which phytoplankton receive enough light to grow. Here, we used the term photo-active layer to decouple it from the term mixed layer, just for the sake of the sentences content. We agree that this was misleading. We will change it to the more common term euphotic zone and describe it.

Line 247: confusing in the same paragraph, nutrients will help for photosynthesis

Response: Thank you for that comment. We think that the nutrients that become available after autumn mixing could be one reason for the algae to bloom.

Line 254: Could we relate that to the slick formation and the effect of CO2 (slow gas-transfer)? If it is what we call a bloom, it should also decrease CO2 via very high photosynthesis.

Response: We agree with both points. In the discussion, we explain high CO2 demand during the day by the algal bloom. The days were windier than the nights. We therefore think that the formation of a slick mat is favored during the nights. Then this mat would further increase the resistance for gas transfer.

Figure 4: here you will need SML sampling o microsensors (possible to use in lakes (?)) :). Also nice work from Alexia D. Saint-Macary

Response: Microsensors are indeed a good method to study gradients at boundaries. We also performed some oxygen microsensor measurements at the water-air interface in the laboratory as well as in a small pond. However, we did not do such measurements in Bautzen. It would be very interesting to try in situ microsensor measurements in lakes in future experiments.

Figure 4: During day, there is also a phytoplankton CO2 release, just that problably the uptake is bigger.

Yes – it's a net uptake.

Also just noticing, sometimes you talk about phytoplankton and sometime algae. In oceanography we use phytoplankton

Response: Thank you for highlighting this. The correct term would be phytoplankton. We will change algae to phytoplankton in the manuscript to use correct scientific terms.