This is a very relevant study as it points to one of the major concerns of the traditional methods to estimate air-water CO2 exchange, the assumption of constant concentration of CO2 in the water. The experiment and data are interesting and well worth publishing. I, however, think that a substantial revision with rewriting and reanalysis is required.

Below are some comments and suggestions, I will not comment much on language, but I think a thorough revision of the writing is necessary as well.

Response: We want to thank you for reading through our manuscript and taking the time to help us improve the work. We are happy to hear that you found it to be a valuable contribution to the field. For a revised manuscript, we will improve the language.

General comments of the introduction:

There exists a range of literature on the role of lakes in the carbon cycle, and this part should be updated base on more and more recent literature. Please look at the papers by Golub et al and Guseva et al for a range of suggested papers.

Response: With our manuscript we focus on CO2 gradients at the water surface, which can affect concentration measurements. This can result in erroneous estimations of fluxes. The focus of our manuscript is not the carbon cycle per se rather the special characteristic of the diffusion at the water surface. We therefore decided to restrict ourselves to 2 references at this point. Of course, there is a lot of literature about the role of lakes in the carbon cycle. The already classical paper by Raymond was the first to review the role of CO2 and in our eyes deserves reference here. We think the Lauerwald reference from 2023 is a good one to present the state of the art.

I think the ambition to look at 5 and 25 cm are good, but the major gradient is closer to the surface, please have a more thorough discussion on this aspect.

Response: We agree that the major gradient is in the surface microlayer. However, with existing instruments it was not possible to monitor CO_2 concentrations at the water surface with better vertical resolution. It is indeed one of the messages of our paper that we need a good method to measure dissolve gas concentrations very close to the surface. We will discuss this point in more detail.

Line 35: There are several EC sites worldwide (see Golub and Guseva).

Response: Compared with studies measuring GHG concentrations, there are only “few” EC measurement systems installed on water sites. However, we agree that more and more EC systems are being installed on lakes. We will change “few” to “a restricted number”.

Furthermore, we want to emphasize that EC measurements are not suitable for small lakes, or measurements there can be limited due to fetch characteristics and probable interfering of the footprint with the terrestrial and amphibious surrounding. Consequently, CO2 measurements in the water are in many cases the only convenient method to quantify GHG fluxes continuously.

Line 50 to 55: The cooling induced convection and the impact on the gas exchange is very important here (in particularly when seeing the strong diurnal cycle in the result section) and should be further discussed also in the introduction. There exists a range of literature from seas and lakes (Rutgersson and Smedman, 2010, Podgrajsek et al 2015, Eugster et al, 2003, 2023; Heiskanen 2014, Andersson et al 2017)

Response: Thank you for this important comment. Our initial intention was to not go into the details of this topic to direct the readers attention to our main research objectives. However, we agree, especially facing our findings regarding the differences in water temperature and air temperature, that a more detailed discussion of this point can be helpful to understand and discuss our results.

Line 75: The study of Rudeberg is interesting and well discusses how spatial and temporal variations influences the flux. It is, however, limited to chambers. Other studies use EC-fluxes (Rutgersson et al, Dong et al).

Response: Thank you for your comment. In our manuscript we tried to focus on the topic of water side concentrations and its measurements. We acknowledge that a lot of research is available on the spatial variability that is measured as spatial average by EC measurement due to the larger footprint, however, we tried to have a concise story about aquatic concentrations. We therefore introduced and discussed the effects that can be observed when using CO2 probes in the water, rather than focusing on the horizontal heterogeneity of fluxes, which can be measured using EC already. We will include additional sentences on that part in a revised version of the manuscript, while keeping the focus on concentration measurements in the water.

I think the limitations of chambers in relation to EC should be further discussed (see for example Podgrajsek et al 2014).

Response: As mentioned above, we tried to focus on the limitations of aquatic CO2 concentration measurements. We are aware of the ongoing discussion regarding the comparison of EC and floating chambers and discussed this with many colleagues in the past years. If we start discussing possible issues with floating chambers we also need to discuss possible issues with EC. In our opinion, this is far beyond the focus of this paper and should be discussed in another manuscript. Floating chamber measurements did not play a role in this work – so we not really see the point in discussing floating chambers in detail.

The surrounding areas is considered unimportant, please ale note the possibility of non-local effects (eeg Esters et al).

Response: Thank you for hinting to this topic. Non-local effects were considered unimportant based on comprehensive investigations, personal observations and experience with the water body. In Spank et al (2023) we did a very detailed footprint analysis and showed that the footprint was not affected by littoral areas and the terrestrial surrounding. Furthermore, the analyses of the energy fluxes (i.e., sensible and latent heat flux) provided by the EC measurement system in parallel to the CO_2 fluxes clearly showed a unique aquatic characteristic, which additionally proofs the minor importance of non-local effects. We also did multiple field campaigns to resolve spatial heterogeneity of CO2 concentrations in the surface water of Bautzen Reservoir, but never found hints of pronounced

differences. In particular, we could not find hotspots of CO2 concentrations during the night. The observed concentration gradients are limited to certain nights, for which we have only the data shown in the manuscript.

Section 2.4: Please do not name the routines used. If this is important explain what they do to the data (if this paper is read in 10 years' time, it might be impossible to understand as now written). The name of the routines could be in an appendix, if the authors consider it important information.

Response: We think that it is good practice and important for the reproducibility of the analysis to mention the functions used. We agree that information about the principles behind those functions is interesting. We will reformulate this and move less important stuff to the supplement.

Results:

In Figure 1 you show a really nice diurnal cycle, with significant gradients during night-time, this is explained by the phytoplankton activity, but you really should consider the effect of physical processes with a strong waterside convection during night-time. This is seen during low winds, when the convection is found to dominate.

Response: Thank you for your comment. In preparation of the manuscript we tried to investigate processes that could explain the observed CO2 gradient, while having condition that favor convection. However, both the atmosphere and the water were in unstable condition, which is derived the difference between water and air temperature, the course of the water temperature profile in surface water and stability measures provided by the EC measurements, but we did not find a robust explanation for the differences in CO2. We agree that our discussion of night-time convection is a bit short. In a revision we will discuss this aspect in more depth, including references recommended by the reviewer.

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