Thank you for taking the time to consider our manuscript. We have reviewed the comments received to address the concerns and your constructive. We have addressed all the comments in the revised manuscript and are grateful for the careful and constructive feedback. The suggestions have substantially improved the clarity and quality of the paper. Below we provide a point-by-point response to each comment, with your comments shown in black and our responses in blue.

Referee: 1

Comments to the Author(s)

The study examines CO_2 fluxes of dry sediments from 14 temperate and 16 Mediterranean ponds in Europe during their dry phase in summer and/or autumn of 2022. These fluxes were measured using chambers. Additionally, sediment and water analyses were conducted to characterize the sites and to investigate the differences.

I read the manuscript with great interest and believe that the study is promising, but that some improvements are necessary.

Reply: Thank you for your time and effort in providing us with constructive feedback to improve our manuscript.

General comments or questions:

- In the abstract, the methodology for measuring CO_2 fluxes is missing.

  Reply: We have now included a brief description of the methodology used for measuring CO_2 fluxes in the abstract in lines 21-22. We aimed to keep it concise, as abstracts typically require a short overview.

- How exactly and to what extent does your study fill the knowledge gap you mentioned in the introduction?

  Reply: We acknowledge the reviewer's comment. Our study contributes new data on CO_2 emissions from ponds during the dry phase that in comparison with other ecosystems is less represented. Our study highlights the importance of incorporating seasonal frameworks that account for the main local factors controlling CO_2 fluxes, such as temperature and water content. Moreover, it introduces hydroperiod length as a first step toward a more integrated understanding of both wet and dry phases, elucidating how transitions from permanent to temporary ponds can affect CO_2 dynamics. However, we recognize that this study represents only an initial step, and further research is needed to fully unravel the complexity and variability of these dynamic ecosystems.

- In the introduction, a concluding sentence on how the questions will be answered is missing.

Reply: We have now added a concluding sentence in the introduction to clarify how the research questions are addressed in lines 94-96. We believe that this addition improves the flow and clarity of the section.

"For this reason, our study aims to address this gap by identifying the main drivers of CO_2 fluxes during dry periods and examining how the preceding wet phase, in terms of hydroperiod length (i.e., the duration of water presence prior the dry phase in a pond throughout the year) influence them, through a comparison of ponds from contrasting climatic regions across two seasons."

- The coordinates of the sampling or measurement points within the sites, the sampling dates, and the names of the studied ponds are missing.

  Reply: We have added a new table in the Appendix (Table A1) that provides the coordinates, the names of the studied ponds, and the corresponding sampling dates (line 526).

- The chamber description still lacks some information (see the detailed comments).

  Reply: We added the requested information in the new version of the manuscript (Section 2.3).

- For me, it is unclear how often or at what frequency the CO_2 measurements were conducted in each season. Were there temporal replicates?

  Reply: We have clarified the frequency of CO_2 measurements for each season. Specifically, measurements were conducted once per season in each pond, and no temporal replicates were performed. This clarification has been included to provide a more accurate description of the sampling design (lines 184-185).

  "Measurements were conducted once per season at each pond during daytime (08:00–19:00 h), with no temporal replicates within the same season (Table A1; S1)."

- In the manuscript, there is no information on whether the data requirements for the statistical tests used (e.g., ANOVA or t-test) are met.

  Reply: We thank the reviewer for this suggestion. As CO_2 emissions did not follow a normal distribution in some cases, we revised the analyses using non-parametric Mann–Whitney tests (Wilcoxon rank-sum test; wilcox_test function, rstatix package; (assambara, 2023). Normality was assessed prior to analysis using Shapiro–Wilk tests (shapiro.test function, stats package). Importantly, the main patterns and differences between groups remain unchanged, while the revised approach provides a more robust statistical framework. We added the information in lines 252-256.

- I miss a conclusion chapter.

  Reply: We thank the reviewer for this comment. A conclusion chapter has now been added to the manuscript (lines 521-526).

  "Our results highlight the need to integrate CO_2 emissions across all stages of the dry season to achieve accurate estimates of fluxes in ponds. Although no significant differences in emissions were observed between climatic regions, key drivers such as hydroperiod length, sediment temperature, and sediment water content are inherently linked to climate. Moreover, ponds with better conservation status emitted more CO_2 during the dry phase; however, a comprehensive integration with emissions from the wet phase is still required. Understanding these dynamics is crucial for predicting carbon fluxes in pond ecosystems under future climate and land-use scenarios."

- The graphics are slightly pixelated, and the image quality could be improved.

  Reply: The images were prepared following the pixel standards recommended on the journal's webpage. However, we acknowledge that some loss of quality may occur during the PDF upload process.

Detailed comments and suggestions:

- Abstract: The methodology is missing

  Reply: As mentioned above a brief description of the methodology has now been included in the abstract. We kept it concise to maintain the abstract's brevity, while providing enough information to understand the general approach (lines 21-22).

- L23ff: What do you mean by hydroperiod?

  Reply: In this study, hydroperiod refers to the duration of time each pond retained water prior to the dry phase, quantified as the number of months with water surface during the 12-month period preceding the last autumn sampling (conducted between late September and November). We have added a brief description in the introduction to clarify this term (lines 94-95).

  "Hydroperiod length (i.e., the duration of water presence prior the dry phase in a pond throughout the year)"

- L26: c.?

  Reply: The abbreviation "c." stands for "circa", meaning "approximately". To improve clarity, we have replaced it with approximately 27 ºC in the manuscript (line 27).

- L37f: It would be good to specify the CO_2 emission value of ponds.

Reply: We have now added some representative CO_2 emission values from the literature as a reference in lines 40-44.
"However, reported CO_2 emissions from ponds are highly variable, ranging from hundreds to several thousand mg C m^{-2} d^{-1}. For instance, ponds of similar size (<0.001 and 0.001–0.01 km^2) reported by Holgerson and Raymond, (2016) emitted on average 254 and 422 mg C m^{-2} d^{-1}, respectively, whereas exposed pond sediments reported by Keller et al. (2020) range from -73 to 11765 mg C m^{-2} d^{-1}."

- L104f: Instead of spanning latitudes or longitudes, it would be better to add the actual coordinates of some sites and refer to the appendix.

  Reply: The coordinates of the sites have now been included in Table A1 in the Appendix, as recommended.

- Figure 1: Since graphs a) and b) are already zoomed in, it would be helpful to include an overview graph with all sites, countries, climate regions, etc.

  Reply: We thank the reviewer for this suggestion. An overview graph including all sites and countries, providing a better zoomed-out view, has been added to the revised manuscript.

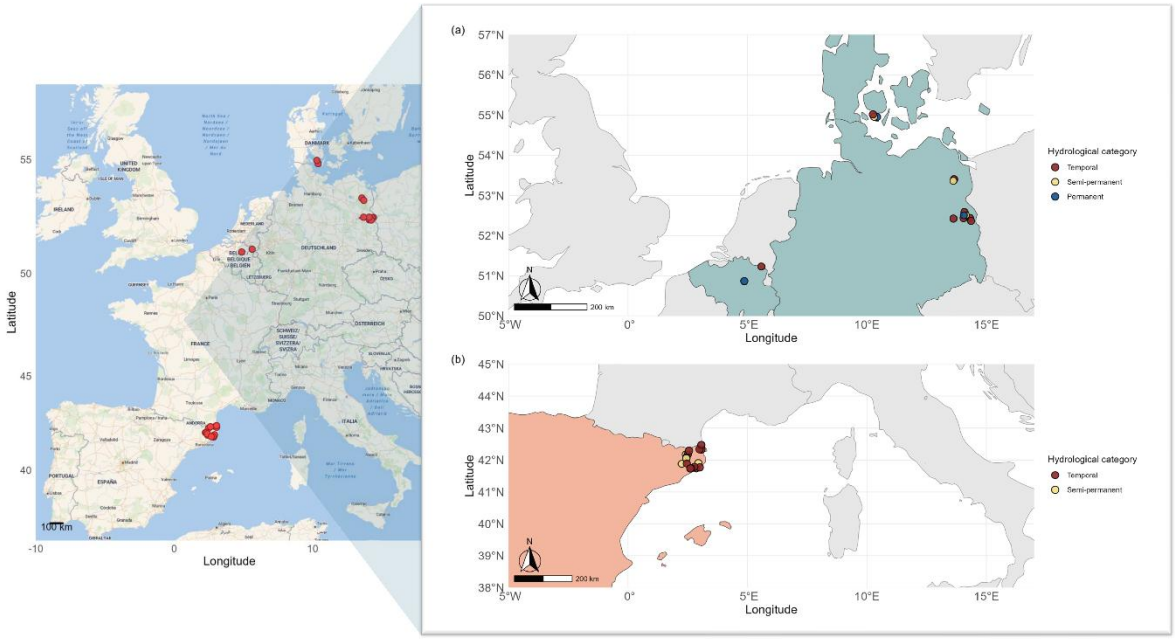

Figure 1: Geographic locations of the studied ponds. Left panel: map created using Stadia Maps outdoors basemap and OpenStreetMap data. Map data © OpenStreetMap contributors, © Stadia Maps (https://stadiamaps.com/). Ponds are highlighted in red. Right panel: map showing ponds categorized by hydroperiod: temporary (dark red), semi-temporary (yellow), and permanent (dark blue). Countries are colour-coded according to their climate regions: Mediterranean (orange) and Temperate (light blue).

- It would be interesting to categorize the sites in Figure 1 according to the dry or wet phase definition written in L109 ff.

Reply: The sites in Figure 1 have now been categorized according to the categorical definition described in L109 ff, as suggested. Indicated in the figure attached above.

- Method chapter: Please use the same description style for each instrument. Currently, it differs. You do not have to repeat it if the instrument is already mentioned.

  Reply: The Methods section has been revised to ensure a consistent description style for all instruments, standardizing the information to include model and brand, and avoiding repetition when an instrument had already been mentioned.

- L117: What do you mean by “dry fluxes”? I also recommend using *N* instead of n for the number of observations/samples throughout the manuscript.

  Reply: In the literature, “dry fluxes” refers to CO_2 fluxes measured from exposed (non-flooded) sediments after the waterbody is no longer inundated. We have clarified this in the revised manuscript (Line 131).

- L123ff: Why were 40-year averages of annual temperatures and precipitation used instead of the more common 30-year averages for the climatic description of sites?

  Reply: We used 40-year averages because the climatic database employed in our study (fifth generation of ECMWF atmospheric reanalysis of the global climate (ERA5) of Copernicus Climate Change Service (C3S) (Wouters, 2021)) provides reference values for the period 1978–2018, which corresponds to 40 years. We considered it appropriate to use the available period rather than artificially truncating the dataset, as the longer time frame reduces the influence of short-term anomalies while still representing contemporary climatic conditions. For year of deviance, we included the year of sampling 2022. So, we can capture the trend and the most accurate of the year.

- L130: You have finally defined what you mean by "hydroperiod length," although the term was already mentioned before. It would have been helpful to define it the first time it was mentioned.

  Reply: As mentioned, brief description of “hydroperiod length” (i.e., the duration of water presence in a pond over the course of a year) has now been added prior to its definition in the Methods section, to clarify the term and improve readability (lines 94-95).

- L157: Why did you use a filter size of 0.7 µm to obtain the dissolved fraction instead of, for example, 0.45 µm?

  Reply: We used 0.7 µm GF/F filters because this pore size efficiently separates the dissolved fraction while retaining phytoplankton and larger particles, and reduces clogging compared to finer 0.45 µm filters. Moreover, the use of 0.7 µm

GF/F filters has been a historical standard in oceanography and limnology, allowing comparability with previous work and consistency in long-term datasets (DFO, 2015; Wetzel and Likens, 2000).

DFO (2015): Fisheries and Oceans Canada, Reference Manual for Limnological Analyses, Publications.gc.ca collection, Fs94-167.

Wetzel, R. G. and Likens, G. E. (2000): Limnological Analyses, 3rd edn., Springer-Verlag, New York, 429 pp., https://doi.org/10.1007/978-1-4757-3250-4.

- L165ff: This subchapter is missing important information about the chamber measurement (e.g., whether it is a through-flow or static system), the chamber type (transparent or opaque), the chamber size (area, height, and volume), and the chamber material. In addition, did you use any additional materials during the measurement, such as tubes or a pump? What time of day did you conduct the chamber measurements at the four to eight spots per pond? How many measurement days were there per season at each pond, and how often were they conducted? Did you correct the measured CO_2 concentrations for water vapor?

  Reply: We have added the requested methodological details in the revised manuscript. In response to the questions:
  We used static, opaque chambers with a surface area of 0.075 m^2 and a total volume of 8 L (diameter 345 mm, height 160 mm). The chambers were made of polypropylene (PP) plastic, and no additional materials such as tubes or pumps were used during the measurements (lines 185-192).
  Measurements were conducted during daytime between 08:00 and 19:00. Since our study design did not include temporal replicates, only one measurement campaign was carried out per season in each pond (lines 183-184). Because the chambers are opaque, preventing light from entering, diurnal variations are recorded indirectly through sediment temperature and moisture. Finally, measured CO_2 concentrations were corrected for water vapor (lines 201-202).

- L167: I am not familiar with the mentioned sensor. What is its precision, compared to a Licor, Los Gatos, or Picarro gas analyzer, for example? At what frequency does this sensor measure during the five-minute closing time?

  Reply: We used Sensirion SCD30 sensors, which can be programmed to measure at different frequencies; in our study, measurements were taken every 2–4 seconds during the five-minute chamber, or one hour chamber closure. While these sensors have a lower absolute accuracy (manufacturer-stated precision ± 30 ppm) compared to instruments such as Licor, Los Gatos, or Picarro analyzers ($< \pm 1$) , the relative changes in CO_2 concentrations are reliable for flux calculations, as only the change over time is relevant. The measurement principle follows Bastviken et al. (2015), who demonstrated that mini loggers can provide cost-efficient and reliable CO_2 flux estimates in terrestrial and aquatic environments (see https://doi.org/10.5194/bg-12-3849-2015 for accuracy

and reliability details). we have explicitly referenced their protocol in the revised manuscript (lines 212-213).

"The measurement approach used in this study follows Bastviken et al. (2015), who provide detailed information on logger preparation, sensor evaluation, calibration, and data processing in their manuscript and supplement."

- L174f: Explain why one measurement had a different sampling technique and measurement time. Was it a one-hour measurement time or a one-hour closing time?

  Reply: For the present study, the 5-minute chamber measurements were used as a standard duration for addressing the CO_2 research questions .The one-hour measurement method was also included, as it is compatible with our study and uses data from the internal CO_2 sensor. This method involved a 1-hour chamber closure with 10-mL samples collected at 10 minutes intervals (0 min, representing ambient air, then 10, 20, 30, 40, 50 and 60 min). For the internal CO_2 sensor, the only difference was the longer measurement period, making these data comparable to the 5-minute measurements. These one-hour measurements were primarily used to calibrate the CH_4 sensor with field data, supplemented by an additional laboratory calibration. Manual gas samples analyzed by chromatography were used to measure CH_4, CO_2, and N_2O. While these measurements are intended for future studies, the CO_2 data from the logger were included in the present analysis as additional replicates, since fluxes were comparable between the 5-minute and 1-hour durations. Also, the CO_2 from gas chromatography could be used to the reliability of sensor-based measurements. However, as our study focuses on fluxes, the absolute concentration is less critical than the relative changes over time, which are reliably detected by the SCD30 sensor for accurate flux calculations.

- L175: What was the size and the material of the vials or syringes? When during the one-hour closing time did you measure, and how much volume did you take? Were your chambers equipped with an overpressure valve?

  Reply: We used 60 mL BD Plastipak syringes to withdraw gas from the chambers and transferred the samples into 5.9 mL Exetainer® vials (Labco). At each sampling time we collected 10 mL of chamber headspace. For the one-hour closure, six samples were taken at 10-min intervals (10, 20, 30, 40, 50 and 60 min). In addition, one extra sample of ambient air was taken at 0 min as a reference. The chambers were not equipped with an overpressure valve.

- L175f: What did you measure with the gas chromatograph? This is unclear to me, as it was never mentioned again in the manuscript.

  Reply: The gas chromatograph was used to measure CH_4, CO_2, and N_2O, as mentioned above. These measurements were not discussed further in the manuscript because they were not directly relevant to the results presented here.

We have clarified this here and revised the manuscript to provide a clearer explanation of the method while removing unnecessary references to these measurements.

- L178: Why did the CO_2 sensor did not require a calibration?

  Reply: The CO_2 sensor (SCD30, Sensirion) measures concentrations in ppm and comes pre-calibrated by the manufacturer. Therefore, no additional calibration was required prior to deployment. A reference to the product datasheet (SCD30 CO_2 and RHT Sensor Datasheet, Sensirion AG, 2020) has been added to the manuscript to clarify this point (line 200).

- L178f: What data did you use for the 3-point average, and why was there background noise?

  Reply: The 3-point rolling average was applied to the raw CO_2 concentration data to reduce background noise prior to flux calculation. Such smoothing is a common procedure to smooth the data before calculating fluxes, due to background noise arises of small, rapid fluctuations in the chamber headspace (pressure, temperature, RH changes) and sensor-internal measurement noise.

- L180: Why did you only use the last two to three minutes of each five-minute measurement period? What is the reference for Equation 1?

  Reply: The initial 1-2 minutes of each measurement period were excluded due to increased signal noise likely caused by humidity and temperature fluctuations immediately after chamber closure. Flux values were derived from the data corresponding to the last 2–3 minutes of each 5-minute chamber closure to ensure more accurate linear flux estimates, as recommended for non-steady-state chamber measurements (Johannesson et al., 2024). The CO_2 flux was then calculated based on the ideal gas law using Eq. (1) (Podgrajsek et al., 2014). Our equation is slightly modified, as we used the molar mass and report fluxes in mg C m^{-2} day^{-1}.

- L182: Why did you choose to use the carbon unit for the fluxes? Additionally, you used hourly units here, but daily units throughout the manuscript.

  Reply: While gas fluxes can be expressed in various units, we report them as CO_2-C. In our study, fluxes are expressed in carbon units (mg C m^{-2} d^{-1}), which allows direct comparison between CO_2 and CH_4 fluxes, following common practice in biogeochemical studies. We have also corrected this error; the fluxes are consistently reported in daily units throughout the manuscript (line 207).

- L190: Milli-Q is a brand name, not a water type.

  Reply: You are right, we now use ultrapure water in the MS (line 217).

- L191: Why did you use 48 hours?

Reply: We followed the standard protocol, and sediment samples were dried at 105 °C for 48 hours to ensure complete water removal. The extended drying duration is particularly important for highly wet or fine-grained sediments, as shorter times may lead to underestimation of moisture content. This procedure aligns with ASTM D2216-19 (Doi:10.1520/D2216-19) and ensures accurate and reproducible results.

- L195: Please cite the references that used this as a proxy.

  Reply: We have included the citation in the revised manuscript (line 223).

- L220: Table S2 is mentioned before Table S1. Please reconsider the order of the tables.

  Reply: We have corrected the errors in the numbering and order of the tables.

- L221f: This sentence could be moved to the next subchapter, "Statistical (or data) analysis".

  Reply: We appreciate the reviewer's suggestion. However, since this sentence refers to the data extraction procedure rather than the statistical analysis itself, we consider that it fits more naturally within the methodological section of dissolved organic matter characterization, rather than in the "Statistical analysis" subsection.

- L224ff: Have you had tested your data for normality?

  Reply: This has been modified in the revised manuscript: our data did not follow a normal distribution in all cases, as assessed by the Shapiro–Wilk test. Accordingly, we applied a Mann–Whitney test. Despite this adjustment, our results remain unchanged, and the explored groups continue to show the same significant differences, now confirmed with the appropriate statistical approach (lines 252-257)

- L259: The R version is important for repeatability.

  Reply: We have added the R version used in the analysis to ensure repeatability (line 293).

- Figure 2: The unit in the y-axis label is missing a bracket. Why does the boxplots have different widths? Does the x-axis label mean Pond ID? To better illustrate the differences and support your results, I would reconsider the representation and categorize by other environmental variables.

  Reply: All issues regarding Figure 2 have been corrected in the revised manuscript. Regarding the suggestion to categorize by other environmental variables, as the main purpose of this plot is to illustrate individual variability among ponds, we believe it would be less clear if the data were further aggregated. We have also added a bracket to indicate which Pond IDs correspond to each climate category.

- L263: Instead of "overall," I would say "on average" that all your ponds were a CO_2 source, as you have also measured a few negative CO_2.

  Reply: The change has been implemented in the manuscript as recommended (line 294).

- L270: Both are red lines. Please be more precise in the description. What is the mean value of?

  Reply: The change has been implemented in the manuscript to better clarify the graph (line 301).

- Table 2: I don't think the abbreviation T-FCO_2 is necessary or correct here. I would rather use the term "CO_2 fluxes" over the four columns on the right, including the unit. Where T-FCO_2 and the unit are now, I would put the mean ± SD. I also recommend including the number of observations.

  Reply: Thank you for your suggestion; the changes have been implemented in Table 2. However, the table has been moved to the Supplementary Material and renamed Table S1 by suggestion of the reviewer 2.

- Figure 3: In the graph, you used n.s., but in the caption, you explained the abbreviation NS. In the supplementary figures, you wrote that an absence indicates no significance. Be consistent.

  Reply: The changes have been implemented throughout the manuscript and supplementary material, and we now consistently use “n.s.” to indicate non-significant results in the figures.

- L299: Here, you wrote ".01"; in L302, you wrote "0.01" for p. Be consistent throughout the entire manuscript.

  Reply: The p-value notation has been corrected for consistency throughout the manuscript.

- Figure 4: What are the R^2 values of the linear regression lines?

  Reply: The R^2 values of the linear regression lines have been added to Figure 4 in the revised manuscript.

- L305: The caption of Figure 4 mentions a dashed line, but I cannot see one in the figure.

  Reply: This element was removed in the latest version of the figure . We have now updated the caption accordingly to ensure consistency with the figure.

- Table 3: I miss the p values you mentioned in L302f.

Reply: The p-values mentioned in L302f have now been added to Table 1 in the revised manuscript.

- Figure 5: I'm not sure what to say about these trend lines. I don't trust them because they look like a point cloud with temperature differences and the influence of the edge effect.

  Reply: To confirm that the interaction pattern is not an artifact of the model, we compared the fitted relationship with the raw data distribution. A supplementary figure (Fig Sr1) attached shows that the slopes of CO_2 fluxes vs. sediment water content differ across temperature levels in the raw data, consistent with the interaction captured by our GLMM.

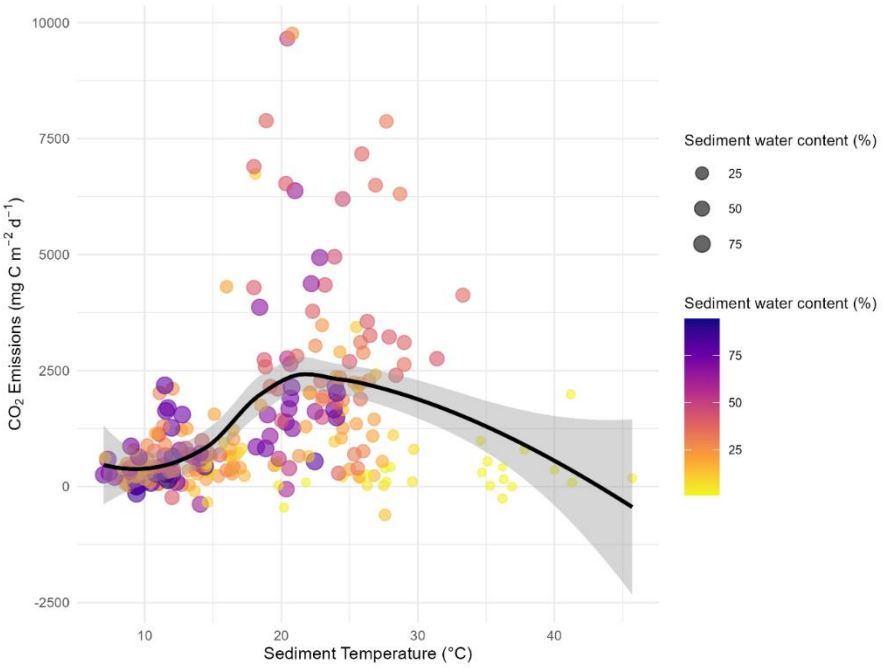

Fig Sr1. CO_2 fluxes trends based on sediment temperature, with dots coloured and sized according to sediment water content. The figure was elaborated using raw data. Lower values are smaller and yellow, while higher values are larger and purple.

- L345: Sometimes there is a space between the number and "Celsius," and sometimes there isn't. Be consistent throughout the manuscript.

  Reply: The errors mentioned have been corrected for consistency throughout the manuscript.

- Table 5: In the text, you always used SD, but in the tables, you used sd. Please be consistent and explain every abbreviation in the table caption. Use the same rounding for all emission values shown here. Since seasonality affects CO_2 fluxes in your studied ponds and in most ecosystems outside the tropics, it would be helpful to know what season the reference values were measured.

  Reply: All the mentioned changes have been implemented in the manuscript.

- L485: The data cannot be reviewed because they are unavailable. I recommend that the authors make the data easily accessible to everyone, not just upon request, for reasons of repeatability and reusability.

  Reply: We thank the reviewer for this comment. The data are currently under embargo because they are part of ongoing doctoral theses. However, they will be made freely accessible once the embargo period ends, ensuring full repeatability and reusability at that time.

- The information about the R packages used is missing and can be added to the references or the methods chapter.

  Reply: The R packages used have now been included in the Methods chapter, and their corresponding references have also been provided in the bibliography.

- Why did you use two appendices (A and B)?

  Reply: We followed the egusphere journal's guidelines, which recommend the use of separate appendices (A and B) to organize supplementary material more clearly. However, if this format does not fully align with the journal's preferences or if another structure is recommended, we will be glad to adjust it accordingly.

- Table A2: Could you add more lines to better separate the categories in the left column and put each variable name in its own row? This would make the table easier to read.

  Reply: We have reformatted Table A2 by adding additional lines to better separate the categories in the left column.

- Figure S1: Variable names, including units, are sometimes split into two lines. This makes the table difficult to read. Please reconsider this.

  Reply: We believe the reviewer is referring to Table S1, after modification rename as Table S2. In response, we have reformatted the variable names, including their units, so that they now appear in a single line.

- Figure S2: In the manuscript, you called it "Pond ID"; here, on the x-axis, it is "Pond Code." Be consistent. The y-axis is missing a unit.

  Reply: We thank the reviewer for pointing this out. The labels have been corrected for consistency, and the y-axis unit has now been included in Figure S2.

- Figure S3: Please include the number of observations for each box plot.

  Reply: The number of observations for each box plot has now been included in Figure S3.

- Figure S4: There is a typo in the x-axis label: months.

  Reply: The typo in the x-axis label of Figure S4 has been corrected.

- Figure S5. The sentence about the absence of an asterisk can be removed from the caption.

  Reply: The sentence regarding the absence of an asterisk has been removed from the caption of Figure S5.