Revision EGUSPHERE-2025-5065

Point by point response to the reviewers:

First of all, we would like to thank the editor and the reviewers for the positive and constructive comments. We carefully revised and improved the article. The followings are response to the comments of reviewers. The line number below is indicated based on the **clean version.**

General Comments

The manuscript presents valuable insights from a two-year measurement campaign of CO_2 fluxes in a tea plantation in China. The study compares plots subjected to different intercropping treatments, providing an interesting perspective by distinguishing emissions from tea rows and inter-row spaces. The discussion is comprehensive; however, additional experimental details would enhance the reader's ability to interpret the results. Aside from this, I have only a few minor comments (see below). Overall, the paper falls within the scope of *Biogeosciences* and merits publication after these minor revisions are addressed.

Response: Thank you very much for your positive comments. We have revised the manuscript and answered the questions point by point. The line number below is indicated based on the clean version.

Specific Comments:

Abstract

1. Lines 28–31: These absolute values are difficult to interpret without broader context regarding tea plantation emissions. Readers will likely be more interested in relative changes compared to control plots, as mentioned in line 41. Please provide relative changes for the total flux as well (see comment on line 41).

   Response: Thank you for the comments Your viewpoint is indeed more accurate. We have removed the average values and replaced them with the relative changes in average fluxes. We revised the description (Lines 29–32).

   "Average tea-row fluxes were 8.7% and 9.5% lower under SM and HM, respectively, compared to CK, indicating emission reductions with intercropping. In contrast, average inter-row fluxes increased by 19.4% under SM and 7.7% under HM, demonstrating pronounced spatial contrasts."

2. Lines 32–33: Specify for which plots midday peaks occurred.

   Response: Thank you for the comments. While diurnal variations differed slightly between tea rows and inter-rows and among different treatments, it is worth noting that, overall, the peak fluxes predominantly occurred around midday. We revised the description (Lines 32–35).

   "Diurnal patterns generally exhibited midday peaks (12:00–14:00), especially in summer and autumn across all tea-rows, and short-term CO_2 pulses were triggered by field operations such as fertilization and pruning."

3. Line 41: The relative changes reported do not correspond to the values in lines 28–31. Be more precise which aggregates are shown and used for the relative changes.

   Response: Thank you for the comments. The reported percentage changes are based on the total annual emissions (derived from the fluxes), rather than on the average flux values alone, and have been revised accordingly as suggested. We revised the description (Lines 41–43).

   "Compared to CK, intercropping reduced tea-row emissions by 7.1–7.9% but increased inter-row emissions by 12.7–28.9% based on the two years cumulative emissions, continuous intercropping significantly decreased overall inter-row emissions over time."

4. Lines 40–45: This section is unclear. Tea-row and inter-row fluxes appear similar in magnitude (e.g., 8.12 CK (tea-row) vs. 9.07 CK (inter-row)). Tea-row emissions decrease by 7–8%, while inter-row emissions increase by 13–29%. How does this support the conclusion that intercropping is a climate-smart management strategy?

   Response: Thank you for the question. This question is of great significance. In fact, the comparisons in the text should be understood within the correct frame of reference. Whether for the tea rows or the inter-rows, the emission data are relative to "tea plantations with no fertilization." For traditional agricultural economic tea plantations, the amount of fertilizer applied is huge. Most importantly, the overall emissions from the "green manure intercropping" tea plantation remain significantly lower than those from conventionally fertilized tea plantations. This demonstrates that intercropping, as an integrated system, has a clear emission reduction effect.

Furthermore, and more importantly, evidence on the temporal scale shows that over the two-year period, emissions from the tea rows continued to decrease, while emissions from the inter-rows dropped significantly in the second year compared to the first. This powerfully indicates that the emission reduction benefits of green manure intercropping require time to stabilize and fully manifest across the entire system, including the inter-rows, highlighting the critical importance of sustained implementation for achieving long-term and stable emission reductions.

5. Add to the abstract: measurement method (flux chambers), campaign duration, and dataset size.

Response: Thank you for the comments. We revised the description (Lines 23–27).

“We employed the static chamber method over a two-year period, with sampling conducted weekly, to investigate how intercropping with *Vulpia myuros* (SM) and a legume–nonlegume mixture of *Lolium perenne* and *Trifolium repens* (HM) influenced spatial CO_2 flux dynamics compared with a no-intercropping control (CK) from tea rows and inter-row zones in a subtropical tea plantation.**”**

Experimental Setup (Lines 164 ff.)

1. Provide more details: plantation size, distances between plots and replicates, age of plantation and tea plants, etc.

Response: Thank you for your valuable and professional comments. The detailed information has been added to Section 2.1 (Lines 161–164) and Section 2.2 (Lines 171–175), respectively.

The added content is as follows:

In Section 2.1 (Lines 161–164):

"The tea plantation was established in 2015; the tea plants are 8–10 years old and arranged in a single-row planting pattern with a row spacing of 150 cm and a plant spacing of 40 cm."

In Section 2.2 (Lines 171–175):

"The experimental tea plantation covered an area of approximately 1000 m². For each treatment, three representative tea rows were selected as three replicates. Adjacent treatments were separated by two tea rows (~3 m), and replicate areas within the same treatment were spaced approximately 5 m apart."

2. Consider adding a schematic (with dimensions) to Figure 1. Clarify whether tea plants were inside the chambers.

Response: Thank you for your constructive comment. Figure 1b is a field photo of the experimental setup. The silver chamber shown is the flux chamber, which fully enclosed the tea plant. We have revised the figure by adding the specific dimensions of the flux chamber next to it in the image. (A photo of the chamber placed in an inter-rows location has also been added to panel b.)

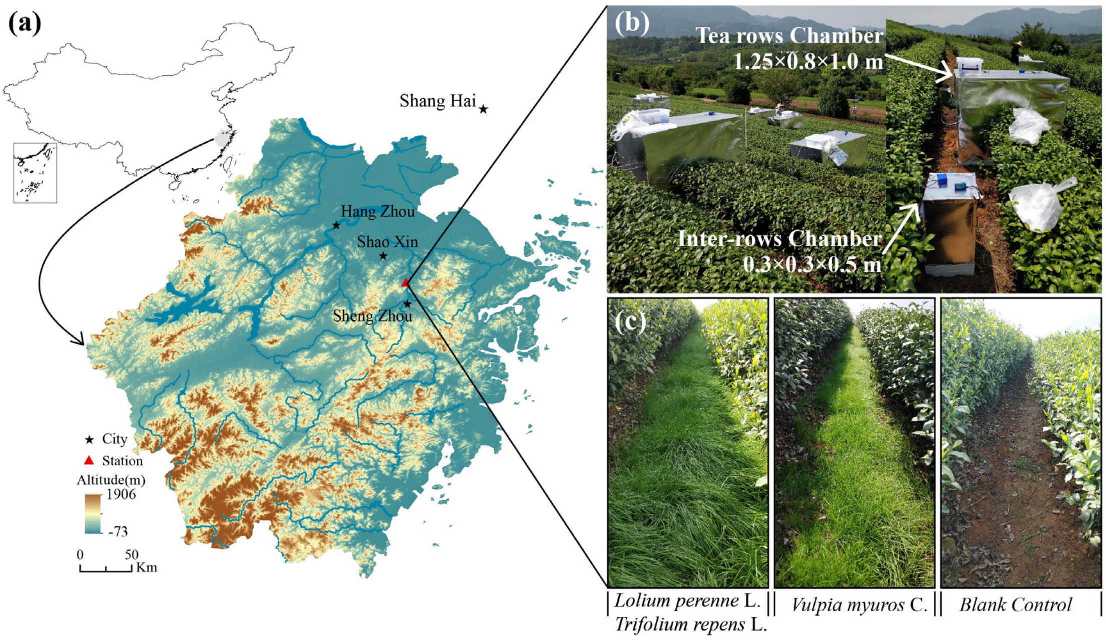


Figure 1. (a) Geographic location of the study area in Shengzhou City, Zhejiang

Province, China; (b) field layout of the tea plantation experiment; (c) photos of *Lolium perenne* L. and *Trifolium repen*s L. plot, and *Vulpia myuros* C. plot, the blank control plot, respectively.

3. According to lines 183–184, one measurement included four samples every 7 minutes: indicate when the first sample was taken after chamber closure and how long (overall) a single experiment took. How high were the CO_2 concentrations at the end?

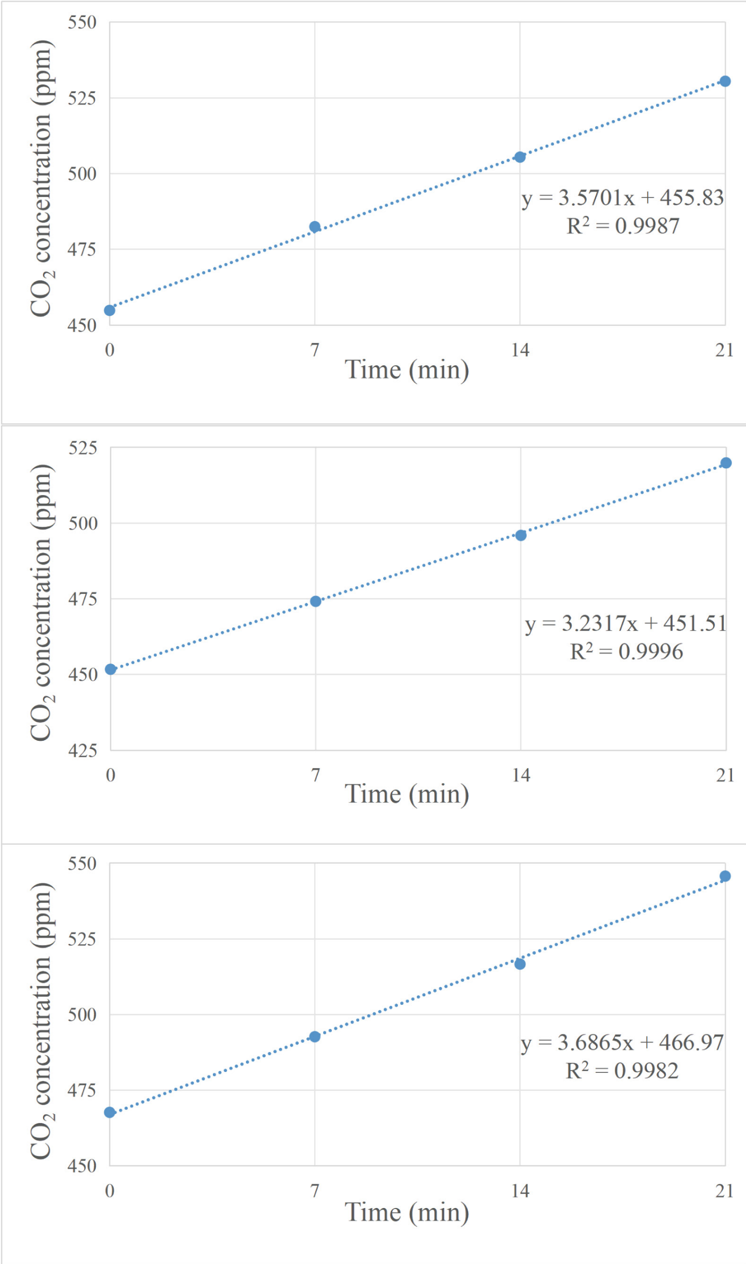
Response: Thank you for your questions. This comment covers several issues; we have addressed each of the points raised below in a point-by-point manner:

We collected four gas samples during the 21-minute period after chamber closure to calculate the flux at each point. The CO_2 concentration of the final gas sample is provided in the representative data table below. Data shown are means ± SE.

Type	Spring (ppm)	Summer (ppm)	Autumn (ppm)	Winter (ppm)
CKT	559.38±9.04	603.10±27.82	586.91±10.10	506.64±5.33f
HMT	550.06±9.72	569.38±23.78	574.68±8.07	507.70±4.94
SMT	550.44±8.61	583.63±24.70	575.51±8.85	503.52±4.85
CKG	705.94±26.25	705.93±30.60	662.62±16.00	563.34±6.88
HMG	719.34±24.49	725.38±34.82	681.12±15.92	559.16±10.55
SMG	740.50±27.08	757.70±36.72	708.70±19.18	581.16±11.75

Include an example showing the 4 measured CO_2 concentrations over time (perhaps in the appendix) and illustrate how fluxes were calculated. Was a linear fit applied to the four data points? How linear was the CO_2 increase? How consistent were the three replicates?

Response: Thank you for your questions. Fluxes were calculated by determining the linear slope from four gas concentration measurements. We added the formula in Appendix 1. All fitted slopes selected for flux calculation exhibited high linearity, with $R^2 > 0.95$. To ensure data reliability, outliers and points with large standard deviations were excluded during quality control. The resulting consistency across replicates is reflected in the standard deviations of the mean fluxes, as shown in Fig. 2b, c. The following figure illustrates the slope of the linear regression of CO_2 concentration over time.



Were all six plots always sampled simultaneously? Did you ever observe decreases in CO_2 concentrations? Figure 2 shows only positive fluxes.

Response: Thank you for your questions. Sampling was conducted sequentially across the six treatments, and each full sampling cycle was typically completed within one hour. Dark chambers covered with aluminum foil were used to measure respiratory fluxes. No significant decline in CO_2 concentration was observed during long-term flux measurements. However, a limited number of negative flux values were recorded during diurnal observations in spring and winter, as detailed in the diurnal variation section.

Include an uncertainty analysis for flux determination.

Response: Thank you for your comments. We added it (Lines 201–208)

"During the tests, the deviation between the calculated regression values of CO_2 and the nominal mole fractions was 0.37 μmol mol^{-1}. The linear fit between the instrument response values and the nominal mole fractions achieved a correlation coefficient (R^2) of 0.9999. Furthermore, the standard gases used were calibrated in multiple rounds by the Greenhouse Gas Laboratory of the Atmospheric Observation Center of the China Meteorological Administration using primary standard gases, ensuring traceability to the World Meteorological Organization primary standards."

Figure and Table Captions

1. Add a condensed explanation of your three letter codes to the different figure/table captions: Something like: CK = control, SM and HM = intercropping types, T = tea row, G = inter-row.

   Response: Thank you for this helpful suggestion. We agree that adding a condensed explanation of the letter codes to the figure and table captions will significantly improve their clarity for readers. Accordingly, we add the following note to all relevant captions: "CK for control; SM and HM for intercropping types, T for tea row, G for inter-row."

Results

1. Line 243: Explain what the uncertainties represent.

Response: The uncertainty mentioned here refers to the standard deviation. We have added a clarification regarding the flux data presentation in the text (Line 239) as follows: "Data shown are means ± standard error (SE)."

2. Line 245: Specify the significance level for "significantly higher."

   Response: Thank you for your suggestion. We have added the notation "($p < 0.05$)" in the "2.3 Data Processing" section (Lines 239–240).

   "In all statistical tests, the level of significant differences and correlations was set at $p < 0.05$."

Figures and Tables

1. Figure 2: Clarify whether error bars indicate uncertainty of a single flux measurement or standard deviation across duplicates.

   Response: Thank you for your comments. The error bars represent the standard error of the mean among repeated measurements. We have added the relevant description in the Figure 2.

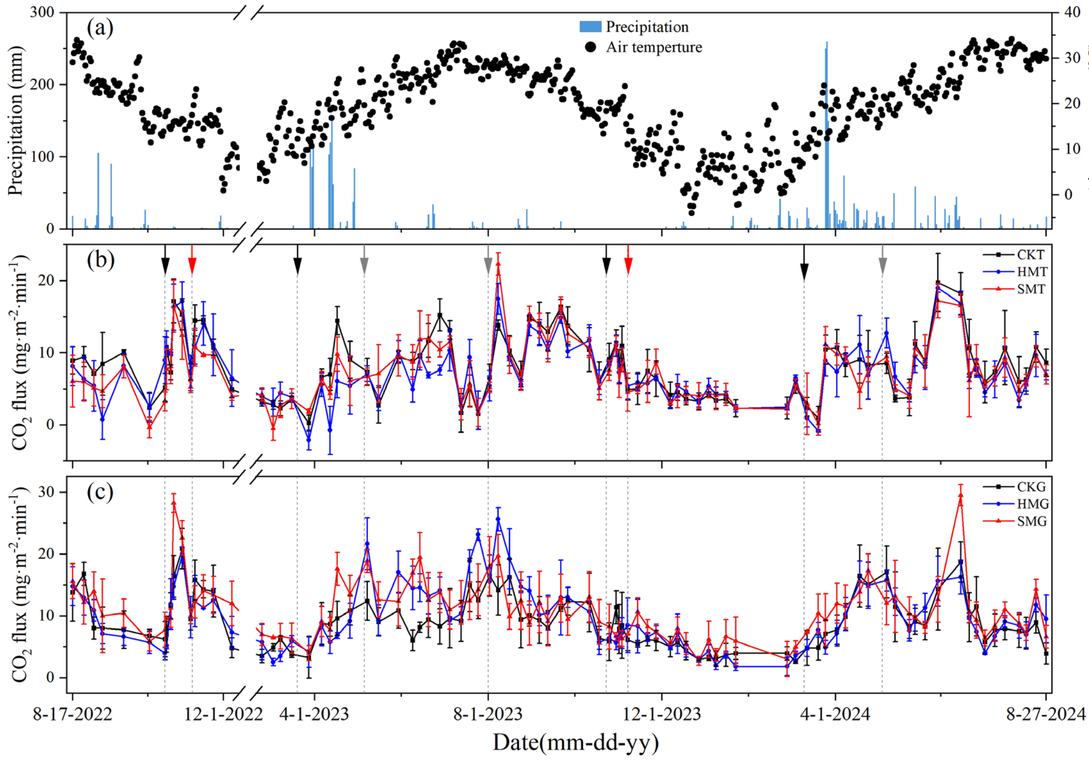
2. Table 1: Explain ± values and superscript letters.

   Response: Thank you for your comments. In this study, data are presented as mean ± standard error (SE). The use of SE is preferred when making inferences about the population mean or comparing the differences between group means. The superscript letters indicate significant differences between seasons and treatment types, as determined by two-way ANOVA. Different letters denote statistically significant differences ($p < 0.05$). we added the descriptions in Table 1.

3. Figure 2: Use a different color for precipitation vs. temperature. Confirm whether

negative CO_2 fluxes were ever observed. Were tea plants present in the chambers?

Response: Thank you for your comments. We have revised Figure 2. Measurements were predominantly conducted on clear mornings, with net CO_2 emissions observed in the majority of cases and only weak negative fluxes recorded at a few time points. The tea plant was enclosed inside the measurement chamber during sampling; it can be seen in revised Figure 1b.



4. Figure 3: Explain superscript letters and error bars. Add "T" for tea row and "G" for inter-row in the legend.

Response: Thank you for your comments. In this study, data are presented as mean ± standard error; superscript letters denote significant groupings based on two-way ANOVA with Tukey's post-hoc test. We added it (Lines 892–893).

"Data shown are means ± SE. Different superscript letters denote statistically significant differences ($p < 0.05$). CK for control; SM and HM for intercropping types, T for tea row, G for inter-row." in the Figure 3 legend.

Results

1. Lines 354 ff.: The consistent differences in soil properties are surprising given the short distances. Provide more detail on plantation history and intercropping duration. When did the intercropping practices start?

   Response: Thank you for your comments. The CKG and SMG treatments were spatially separated by three tea rows (approximately 5 m). Green manure intercropping was maintained for two years, with sowing conducted each November and decomposition occurring by August of the following year. Under the SM treatment, which involved continuous coverage of *Vulpia myuros* over two years, hence changes in soil properties were observed. The presented data represent the two-year averages of soil ammonium-N and nitrate-N concentrations. We added more detail on plantation history and intercropping duration. (Lines 161–164; 171–174; 178–180)

   "The tea plantation was established in 2015; the tea plants are 8–10 years old and arranged in a single-row planting pattern with a row spacing of 150 cm and a plant spacing of 40 cm."

   "The experimental tea plantation covered an area of approximately 1000 m². For each treatment, three representative tea rows were selected as three replicates. Adjacent treatments were separated by two tea rows (~3 m), and replicate areas within the same treatment were spaced approximately 5 m apart."

   "Basal fertilization and tillage were conducted in middle of October, followed by green manure sowing in early November."

Conclusions

1. Line 587 refers to the mitigation of carbon losses. Quantify overall CO_2 emission reductions when summing tea-row and inter-row fluxes for HM, SM, and CK. Data (e.g. in abstract, see my comment there) do not support it and Figure 3 suggest reductions only for HM in the second year. If mitigation exists, contextualize its

potential impact at larger scales.

Response: Thank you for your comments. The values mentioned are relative to the CK treatment, and we have added "compared to the CK" in line 602. We also recognize that the net mitigation effect at the small plot scale over a two-year period may be limited. The mitigation effect is primarily manifested as a significant reduction in emissions from the tea-row zone, which offsets the initial increase observed in the inter-row area. The clear declining trend in inter-row emissions under the HM treatment in the second year suggests that the initial emission pulse was likely a transient response to soil disturbance during the green-manure establishment phase, and that its mitigation potential strengthens over time. Future management could be optimized to maximize emission reduction in tea rows while minimizing disturbance in inter-row areas, thereby enhancing the overall net benefit.

2. Add general considerations on intercropping: benefits and drawbacks (costs, labor, temperature effects, soil compaction, aeration, etc.). Large-scale adoption depends on whether benefits outweigh additional costs.

Response: We thank the reviewer for raising this important perspective. We agree that the widespread adoption of any agricultural technology depends on its net benefits. We revised the description (Lines 611–620)

"Continuous green manure intercropping over two years significantly reduced inter-row CO_2 emissions, and the HM treatment suppressed fertilization-induced emission peaks. These findings demonstrate that green manure intercropping, particularly mixed legume and non-legume combinations, can effectively alter the spatial pattern of CO_2 emissions and mitigate carbon losses. Moreover, this practice provides significant co-benefits like improved soil aeration and fertility, reduced chemical fertilizers, weed suppression, and promoted tea plant growth, thereby offsetting the extra costs in labor and seeds. Therefore, green manure intercropping emerges as a practical and multifunctional strategy for reducing carbon emissions in agroecosystems."