

**Date:** Thursday, September 26, 2024

To,

Russel Dickerson  
Handling Editor  
**Atmospheric Measurement Techniques**

Sub.:- Submission revision RC1 of research paper to the atmospheric measurement techniques

Dear Sir,

Greetings of the day, I hope you are doing well! With reference to the above-cited subject, we are resubmitting herewith the revised version of research paper on **“A simplified system to quantify carbon dioxide, water vapor and heat within a maize canopy (egosphere-2024-2041)”** to your esteemed journal **“atmospheric measurement techniques”**. Authors are grateful to the reviewer for a careful and helpful analysis of our manuscript. Undoubtedly, due to the Reviewer`s comments, the manuscript has been significantly improved. All the reviewer`s comments are reasonable, and we have corrected the MS in accordance with the comments and suggestions

Thank you for receiving our manuscript and considering it for further processing. Authors appreciate your valuable time and look forward to your response.

Sincerely yours,

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## Major Comments

Comments: Figure 2: In the caption, the authors note that the vertical lines represent stable periods where measurements are suitable for recording. The vertical lines and how they are placed in the figure does not seem to support the text in lines 148-151. The text suggests that feeding in a known amount of CO<sub>2</sub> (430 ppm) and looking stability of these measurements define the periods of acceptable data. Based on Figure 1, intake tubes 1 and 2 (3 and 4) are coupled with a smooth transition from one intake tube to the other, while rapid increases and decreases occur as the measurement sequence switches from 2 to 3 and 4 to 1. If useful data is defined by obtaining the ambient CO<sub>2</sub> for this test example, then the stability regions in the plot should be represented by time periods between the vertical solid and dashed lines in the annotated Figure 2 plot shared below. If this is not the case, then the authors need to improve the explanation of this plot, because it would seem undesirable to isolate and use the measurements when CO<sub>2</sub> is 0 ppm as suggested in Figure 2 with the second and fourth vertical black lines. Lastly, why do measurement heights for tubes 2 and 4 record less data with respect to time compared to tubes 1 and 3 when measuring 430 ppm of CO<sub>2</sub>? I would think that achieving an approximately equal number of data points for each measurement height is preferred. Please address this.

- After careful consideration, we decided to remove Table 1 (IRGA output for the multiport air sampling system, for CO<sub>2</sub> conc. (430 ppm) fed through the sampling lines at ambient pressure) and Figure 2 (The time-dependent relationship between the infrared gas analyzer (IRGA) in the multiport air sampling apparatus for a gas concentration of 430 ppm CO<sub>2</sub> flowing at <1 L/min) from the manuscript, as it raised additional questions and complexities not central to the primary objectives of our study. The initial purpose of this figure was to demonstrate that the instrument was accurately measuring a known CO<sub>2</sub> concentration (430 ppm) using different intake tubes, which was a verification step supporting the field trial described in the text that follows. In the revised manuscript, we have clarified that both N<sub>2</sub> (0 ppm CO<sub>2</sub>) and CO<sub>2</sub> (430 ppm) were used to test the stability of the system and confirm that the analyzer and switching mechanism were functioning correctly. We believe that the removal of this figure enhances the clarity and focus of the manuscript.

Comments: Lines 179-181: If the authors were able to improve the set-up to measure at 3.2 seconds compared to 4.9 seconds, then the authors should show the plot with improved timing. The authors can show both figures with a panel dedicated to each that shows contrast. This is strongly encouraged.

- Thank you for bringing this to our attention. We made a mistake. In fact, actual timing for measurement was 3.1 seconds and 4.4 seconds were ignored during the CO<sub>2</sub> reading by the analyzer. This has been briefly explained in the revised manuscript.

Equation 2: The form of this equation uses two assumptions defined in Montagnani et. al. 2018: a homogeneous footprint and that the flux divergence can be ignored. While I have more confidence in the first assumption given that the survey region is a large maize field, I have concerns about neglecting the flux divergence term, especially during transitional periods (i.e., sunrise/sunset) where these calculations seem very important (e.g., Figures

5-7). If the goal is to minimize the error in the total surface budget, then how does neglecting the flux divergence term contribute to the budget error? The authors should comment on this explicitly and note any caveats. It would also be a good idea to acknowledge this shortcoming and work towards evaluating these assumptions used when calculating storage terms.

This matter is central to the evolving research campaign at the University of Tennessee. First, we see Eq. 2 as a gross approximation. The heat storage term of relevance to the surface heat budget must necessarily include heat stored in the biomass and in the layer of soil above the level of G determination. The accuracy of the measurement of G is another item that contributes to the resulting dilemma. The matter of heat storage in the air below the height of EC measurement was examined in the very early days of EC development and was ignored until studies over forests were started in the 1970s. These showed that the top priority was heat storage in the biomass, not in the air. Our use of Eq. 2 here is in recognition of what the ICOS community is doing, as an example of how the multiport system could be productively used. It should not be seen as an endorsement of the protocols adopted by ICOS.

One of us (Oetting et al., 2024) has already examined the spatial uniformity issue, with results that support our present understanding that heterogeneity is likely to remain a problem with relying on eddy covariance methodologies. Better is to make relevant measurements as close to the surface as is possible and hence to minimize the consequences of the difficulties that arise.

It is hard to separate flux divergence issues from the spatial heterogeneity (and topographic) problems that have already been addressed by this same group of workers (see various papers by O'Dell, Hicks, Eash and Oetting).

Height of vertical measurements: The authors note that the height of measurements was adjusted with the growth cycle during the two-month period. The authors should present a table or a stacked bar graph showing height adjustments to measurements as a function of time so that readers know how often the heights were adjusted and the range of heights that were used in this analysis. Furthermore, it is recommended and strongly encouraged that the storage term calculations be conducted for each set of measurement heights to highlight how the storage terms evolved during the growth cycle. The results in their current form mask the growth cycle, which is no doubt an important contribution to CO<sub>2</sub> and H<sub>2</sub>O storage, photosynthetic response and evapotranspiration. I suspect that changing the height of measurements does not change the result too appreciably given profile linearity. However, I wonder how the slope of profile linearity changed during the growth cycle. These kinds of analyses would strengthen the paper and support the approach and instrument set-up presented in the paper.

- We have now included a table (Table 2) that presents the height adjustments of measurements throughout the growth cycle, along with corresponding changes in

the maximum and minimum storage terms. This table demonstrates how storage terms evolved with the crop's growth stages over the two-month study period. As the maize was in its early growth stage during the study, the canopy was not fully developed. Consequently, while the CO<sub>2</sub> storage did not show significant changes, there were substantial variations in the sensible and latent energy storage terms as the crop grew. These findings are now discussed in the revised manuscript, especially in relation to Table 2.

Shading in Figures 5-7: There is nothing in the text discussing the shading in these figures. I assume that the shading represents the variability within the two month period, but nothing is discussed about this shading. I do find it unlikely that there was almost no variability in CO<sub>2</sub> during the day over the two month period, and that the results are almost flat (hovering around 350 ppm). The authors need to add a discussion explaining the shading, and it is strongly encouraged to go back into the data to examine variability at each half-hour averaging interval examined during the diurnal cycle.

- Different colors of the figures correspond to different measurement heights. The shading of the plots represents bands of width +/- one standard error. The variability of CO<sub>2</sub> was found to be higher at nighttime than in daytime. The highest variability was recorded within the canopy at height 1 (0.11 m) and height 2 (0.4- 1.4 m). For most of the daytime, the sub-canopy CO<sub>2</sub> concentration remained at 350 ppm until about 0600 LT when the pooling of CO<sub>2</sub> started.

Lines 302-303: The statement "...followed by a rapid decrease and negative storage until 2000 UTC" does not seem to support what is seen in Figure 7b. Sure, there was a sharp decline, but what followed was a fair amount of positive (accumulation) and negative (depletion) storage between this time period that does not lend support to this statement. The variability was large. Please revise messaging.

- Thank you for your observation. The figure 7 callout was wrong in the previous version and has been corrected in this revision.

Lines 295-297; 301-302: The authors claim that the sensible and latent fluxes exhibit similar characteristics. They do not.

- Yes, we agree with you, sensible and latent fluxes exhibit similar characteristics. We have updated the explanation in the revised manuscript.

Lines 288-290: The authors start out talking about morning and evening transitions, but only comment on the morning transition. This leads to a confusing interpretation if the reader views the statement made at the end of the sentence applicable to both morning and evening transitions when in fact it is not. Please comment on both and make the discussion on respective transitions clear.

- Thank you for your observation. We have now briefly described the morning and evening transition of CO<sub>2</sub>-H<sub>2</sub>O fluxes, CO<sub>2</sub>, latent and sensible heat storage in the revised manuscript.

Lines 295-297; 301-302: The authors claim that the sensible and latent fluxes exhibit similar characteristics. They do not. Lines 302-303: The statement "...followed by a rapid decrease and negative storage until 2000 UTC" does not seem to support what is seen in Figure 7b. Sure, there was a sharp decline, but what followed was a fair amount of positive (accumulation) and negative (depletion) storage between this time period that does not lend support to this statement. The variability was large. Please revise messaging.

- Thank you for your comment. We agree that the sensible and latent fluxes do not exhibit similar characteristics, and we have revised the manuscript to accurately reflect this. Yes we observed that there is positive (accumulation) and negative (depletion) storage between the indicated time period. We have revised the discussion to better reflect the observed fluctuations and variability in the data, as seen in Figure 7b.

Lines 304: I believe the authors can avoid the statement "presently unexplained" by studying Equation (2) and examining Figure 6. This is where the slopes in the profile collapse and an inflection is observed (i.e., concentrations begin to decrease). So the time rate of change of concentrations using the discretized form in Equation (2) should help you form a hypothesis, especially since this is during a period where the stable boundary layer forms. It should also be noted that while the peak in Figure 7b stands out during 2000 UTC, it is not considerably larger than some of the peaks and troughs between 900 UTC and 2000 UTC that reach magnitudes close to 2.5 W/m<sup>2</sup>.

- Thank you for noticing this. We have removed the statement "presently unexplained". Yes, we agree that while the peak at 2000 UTC in Figure 7b stands out, it is not significantly larger than the other peaks and more variation can be seen between 0900 UTC and 2000 UTC. It was recorded that latent heat storage magnitude reached close to 2 W m<sup>-2</sup> between 900 UTC and 2000 UTC when a stable boundary layer formed. This clarification has been incorporated into the revised manuscript.

Lines 303-305: Negligible? Visually I see statistically negative values during the night. The statistically negative latent storage (or depletion) follows a drop in water vapor concentration. The mechanisms for evapotranspiration are minimized and the uptake of moisture into the atmosphere near the surface is reversed as temperatures cool and condense at the surface.

- Thank you for your observation. Our use of the term "negligible" was intended to refer to the small positive storage of sensible energy during certain periods. We agree that, visually and statistically, negative latent storage (or depletion) occurs during the night, following a drop in water vapor concentration. At night temperature decreases, evapotranspiration is minimized, and condensation occurs. We have revised this section to clarify this point in the updated manuscript.

The authors sort of allude to this in lines 272-277, but fail to link these results when discussing Figure 7.

- Thank you for your observation. We agree that the link between the discussion in lines 272-277 and Figure 7 was not clearly made. In the revised manuscript, we have now explicitly connected the results discussed earlier with the interpretation of Figure 7. We elaborated on how the processes mentioned in lines 272-277, such as CO<sub>2</sub> and heat flux dynamics, directly relate to the patterns observed in Figure 7. This additional explanation provides a clearer narrative and helps readers better understand how these factors contribute to the overall results.

Lines 301-313: Discussion in this paragraph is filled with erroneous statements and broad remarks. Dive deeper into the analysis of this figure and make the interpretation clearer and stronger.

- Thank you for your comment. Actually, the current paper focused is just instrument and how this instrument can advance or update the science involved in the CO<sub>2</sub>, H<sub>2</sub>O and fluxes and their storage terms measurement. Our next study is to provide the detail on the fluxes and storage terms. However, we have carefully reviewed and revised the discussion in the mentioned paragraph. In the revised version, we have provided a more in-depth analysis of all the figures and provide additional wind speed and precipitation figures to explain the underlying processes with stronger interaction of the factors. We have expanded the discussion with the support of relevant literature.

Conclusions: The key findings are not summarized nor are caveats and shortcomings of the approach laid out. The conclusions would also benefit from statements related to future work.

- Actually, the current paper has only focused on instrumentation. However, In the revised manuscript, we have included a more detailed summary of the key findings in the conclusion section. We highlighted the main outcomes of the study, including the effectiveness of the multiport system in measuring CO<sub>2</sub>, heat, and water vapor profiles within and above the maize canopy. Additionally, we have addressed the limitations of the approach, such as potential errors in measurement due to sensor placement, power issue, external environmental factors like condensation etc. Furthermore, we have added statements on future work, including the need for further testing in different crop types and environments and its applications in agricultural, forestry and environmental research.

### **Minor Comments:**

Line 49: Insert “the” between “improve” and “understanding”

- “The” has been added between improve understanding in the revised manuscript.

Line 56: can remove “, distributed”

- The word “, distributed” has been removed from the revised manuscript.

Lines 72-73: Comment on “loss of low- or high-frequency flux components”: What does this mean exactly? Was a filter applied? Resolution limitation? Was it the technique used? Please elaborate and add a reference if possible

Line 73: Remove “etc.”

- “etc.” has been removed from revised manuscript

Lines 80-81: Perhaps instead say “Quantifying storage terms is challenging because measurements are required within and above the canopy”. The current sentence is awkwardly phrased.

- The sentence has been rephrased according to the reviewer’s comment.

Lines 107-108: remove “in their series of field experiments”

- “in their series of field experiments” has been removed from manuscript.

Line 110: Remove comma between “interest” and “within”. There are a lot of other examples of misplaced commas.

- Commas has been removed between “interest” and “within”. Furthermore, all extra commas have been removed.

Line 115: replaced “and” with “as” before “well”.

“and” has been replaced with “as” in the revised manuscript.

Lines 120-121 and Lines 154-155: In the first set of lines the authors remark on cycling through all heights every minute while the second set of lines indicates every 30 seconds. Which is it?

- Thank you for pointing out the confusion. We apologize for not conveying this clearly. The system completes a full cycle of readings from all four heights in one minute. Specifically, it takes 7.5 seconds to take a reading from each height, and each height is measured twice (for a total of 15 seconds per height). Therefore, the entire process of reading from all four heights takes 60 seconds ( $15 \text{ seconds} * 4 \text{ heights} = 60 \text{ seconds}/1 \text{ minute}$ ).

Line 195: change “variables” to “measurements”

- “variables” has been changed with “measurements” in revised manuscript.

Line 204: Add “in Figure 4” between “map” and “represents”

- “in Figure 4” has been added between “map” and “represents” in revised manuscript.

Lines 206-207: How did the authors account for the slope of terrain on sonic anemometer wind measurements since the plot indicates the circle is in 5-9% grade? Was the sonic anemometer orientated horizontally or was post processing done?

- The sonic anemometer was mounted and adjusted horizontally and precisely level. The measurement axis was parallel to gravity. Planner fit method as a post processing technique was applied for wind measurements using the ICOS methods

Line 207: How does the soil type factor into interpreting the results in this analysis? Soil type is important for moisture retention, capacity, and subsurface transport.

- Soil type is an important factor that impacts energy balance closure of the system by influencing physiochemical properties importantly soil temperature, moisture and other. Soil type strongly influences the storage and transfer of heat within the soil. In current study, we do consider soil heat storage, but this is of great interest to us, and we will consider it for our next canopy storage term study.

Line 226: Be clear about. Is it the separation distance between measurements? If so, then the thickness for the bottom measurement would be between the surface and the measurement height (0.11 m).

- Yes,  $\Delta z_i$  is the vertical extent of the corresponding  $i$ th air layer (i.e. vertical segment). It represents the thickness of each layer (in our case thickness of each profile height) from the bottom of the 1<sup>st</sup> height (0.11m) towards the surface of the next measurement height.

Line 227: I'm guessing that "N" equals 4, but this not stated explicitly

- Yes, N is the number of sampling points as in our case N is equal to 4.

Line 237: "assumptions made elsewhere" should be backed up by citations.

- Citations (Galliche and Hunt, 2002; Verma and Rosenberg, 1976) have been added in the revised manuscript.

Line 241: "with that aloft"? Or "with air aloft" or "with the overlying atmosphere"

Yes it "with the overlying atmosphere" and has been added in the revised manuscripts.

Line 245: can replace ", such that" with "as"

- ", such that" has been replaced with "as" in revised manuscript.

Paragraphs in lines 240-246 and 247-257 share a lot of redundant information

- The paragraphs in lines 240-246 and 247-257 have been rewritten and make the message clearer for readers.

Lines 299-300: "returning nearly to zero". Its not actually zero

- Yes, it is not zero, but it increases positively (accumulation) after 0700 LT, we updated in the revised manuscript.

Line 218: move "be" between "necessarily" and "site-specific" before "necessarily"



- “be” has been moved between “necessarily” and “site-specific” in revised manuscript.

Lines 252: Question on the sentence beginning with “Soil respiration”. Are you referring to the entire diurnal trend, day portion or night portion? The sentence that preceded this one focused on the pattern at night, and as such, leads to confusion when interpreting the “Soil respiration” sentence.

- Yes, the sentence focuses on the night pattern but in the soil respiration sentence, we conclude in a single line by that the overall pattern of CO<sub>2</sub> flux and storage is influenced by the diurnal change of soil respiration, photosynthesis, and temperature pattern.

This has been made clear in the revised manuscript.

Line 253: It is remarked that wind speeds decreased at night. Statistically, this may be true, but moderate to strong winds can develop at night which would effect the results and add to the variability observed and not discussed. At a minimum the authors should note that they confirmed the diurnal wind structure. They wouldn’t need to show it, just make it clear that this was observed during the two-month survey period.

- Dear reviewer, We agree with your remarks on wind speed. Actually, this paper is focused on instrumentation, how these instruments help to better understand and examine the CO<sub>2</sub> and H<sub>2</sub>O storage terms. How this instrument can advance science involve in modeling etc. Our 2<sup>nd</sup> studies focused on all these parameters, However, I have provided and explained the diurnal wind structure and precipitation for the two-month survey period.

The authors never discuss the time range that this study was conducted. Please indicate the months that this study took place before introducing Figures 5-7. This should be discussed in Section 3.

- The study was conducted from May to end of June 2023 and has been described in section 3 in the revised manuscripts.

Line 265: Replace “, we recorded” with “is”

- “, we recorded” has been replaced with “is” in revised manuscript.

Line 268: “height increased”. The height of what increased?

- It means as the measurement height increases (from height toward height 4) H<sub>2</sub>O concentration decreased. It has been clear in the revised manuscript.

Line 271: The “profile appears to be stronger than” is not an appropriate description of the profile. I think what the authors meant to say is that the profile is steeper or that there is a more pronounced vertical gradient.

- The description in the revised manuscript has been updated with appropriate description according to author suggestions.

Line 271: Remove “cases” after H<sub>2</sub>O

- “cases” has been removed after H<sub>2</sub>O in the revised manuscript.

Line 272: Remove commas between “for H<sub>2</sub>O”

- Commas has been removed in the revised manuscript.

Figure 6 caption: You can omit “pattern” after “profile”

- “pattern” has been removed after “profile” in the revised manuscript

Line 286: Change “diurnal average” to “average diurnal”.

- “diurnal average” has been changed to “average diurnal”. In the revised manuscript.

Line 287: Change “higher values” to “larger magnitudes and more variation”. Higher values could mean more positive. As such, I would instead go with the suggested change. Can also remove “as” between “nighttime” and “compared”.

- We agree with the reviewer’s suggestion. “higher values” has been changed with “larger magnitudes and more variation”. Also “as” has been removed between “nighttime” and “compared” in the revised manuscript.

Line 295: Sensible heat energy storage was not always lower than latent heat storage. Also, references to “7b” and “7c” are incorrectly placed here and elsewhere in this section.

- We agree the sensible heat energy was not lower. I want to say that variation in the sensible energy storage was lower as compared to the latent energy storage. It is updated in the revised manuscript. We apologize for misplaced of 7b and 7c figure but placed correctly in the revised manuscript.

Lines 293-294: Comment on “During nighttime and morning, these processes were reversed, leading to CO<sub>2</sub> storage”. During the morning transition the CO<sub>2</sub> storage becomes negative (depletion) while during the night storage increases (accumulation). Make this clear instead of just saying “leading to CO<sub>2</sub> storage”.

- Thanks for the comments. It has been clearly explained in the revised manuscript that during nighttime and morning, these processes were reversed, leading to CO<sub>2</sub> storage. During the morning transition the CO<sub>2</sub> storage becomes negative (depletion) while during the night storage increases (accumulation).

Missed opportunity connecting Figures 7a and 7b: The authors should dig into the inflected results between CO<sub>2</sub> storage (7a) and latent energy storage (7b) that occur between 0630 UTC and 0900 UTC during the hours following sunrise. Note the importance of both CO<sub>2</sub> and water to photosynthesis which activates at the time where the inflected behavior is observed.

- Soil microorganism activities and respiration from soil-pant surface increase over the sunrise as temperature increases, resulting in CO<sub>2</sub> release and accumulation near the soil surface and within the canopy which leads to observed CO<sub>2</sub> storage (Raza et al., 2022; Davidson and Janssens, 2006; Ryan and Law, 2005). More importantly, mostly at nighttime a stable boundary layer forms due to calm wind conditions which traps the CO<sub>2</sub>. At sunrise due to temperature rise, the layer begins to weaken. The trapped CO<sub>2</sub> mixes with air, disperses, and decreases CO<sub>2</sub> storage on sunrise (Stull, 20012).

The higher latent heat storage is due to the latent heat of vaporization, sunlight first hits the dews on the surface and initiates the evaporation which leads to greater latent heat flux, and water vapor stored in the atmosphere leads to higher latent heat storage (Jacobs and Nieveen, 1995).

Raza, T., Qadir, M.F., Khan, K.S., Eash, N.S., Yousuf, M., Chatterjee, S., Manzoor, R., ur Rehman, S. and Oetting, J.N., 2023. Unrevealing the potential of microbes in decomposition of organic matter and release of carbon in the ecosystem. *Journal of Environmental Management*, 344, p.118529.

Davidson, E. A., & Janssens, I. A. (2006). Temperature sensitivity of soil carbon decomposition and feedbacks to climate change. *Nature*, 440(7081), 165-173. doi:10.1038/nature04514.

Ryan, M. G., & Law, B. E. (2005). Interpreting, measuring, and modeling soil respiration. *Biogeochemistry*, 73(1), 3-27. doi:10.1007/s10533-004-5167-7

Jacobs, A.F. and Nieveen, J.P., 1995. Formation of dew and the drying process withincrop canopies. *Meteorological Applications*, 2(3), pp.249-256.

Stull, R.B., 2012. *An introduction to boundary layer meteorology* (Vol. 13). Springer Science & Business Media.

Line 298: change “After that, this” to “Afterwards the”

- “After that, this” has been changed to “Afterwards the” in the revised manuscript.

Lines 299-300: “returning nearly to zero”. Its not actually zero

- Thank you for the observation. We agree with the reviewer that the values do not actually return to zero, but instead revert to positive (accumulation) values. We have made the necessary clarification and updated the wording accordingly in the revised manuscript.

Line 305: Insert “afternoon into” between “the” and “late nighttime

- “afternoon into” has been inserted between “the” and “late nighttime” in the revised manuscript.

Figure 7: There is not a comment about how the data is being processed to form the plots. Is the data vertically integrated? I'm guessing not given the units. If so, what height are the authors choosing or is vertical averaging done? Y-axis label in Figure 7b has a parenthesis that shouldn't be there. Please place the a-c labeling in a corner and not over the plots.

- The data processing involved averaging the raw data into 15-minute intervals. The data was analyzed using EddyPro 4.1 software, which processes the raw data by applying block averaging and filtering out outliers based on Reynolds decomposition. Additionally, statistical analysis was performed in R Studio to generate the plots that depict the variation. This approach ensures accurate representation and analysis of the storage terms. Yes, the data is vertically integrated in this instance. A parenthesis in fig 7b has been removed and labeled has been placed in the corner of the graph in the revised manuscript.

Line 313: Change from “the accurate estimation of flux” to “the accurate estimation of fluxes”

- “the accurate estimation of flux” has been changed to “the accurate estimation of fluxes” in the revised manuscript.

Figure 7a: How do you explain the large variation between negative and positive CO<sub>2</sub> at night and virtually no storage/no variability during the day?

- During the morning to onward, transition of the CO<sub>2</sub> storage becomes negative (depletion) while during the night storage increases (accumulation). Soil microorganism activities and respiration from soil-pant surface increase over the sunrise as temperature increases, resulting in CO<sub>2</sub> release and accumulation near the soil surface and within the canopy which leads to observed CO<sub>2</sub> storage (Raza et al., 2022; Davidson and Janssens, 2006; Ryan and Law, 2005). More importantly, mostly at nighttime a stable boundary layer forms due to calm wind conditions which traps the CO<sub>2</sub>. At sunrise due to temperature rise, the layer begins to weaken. The trapped CO<sub>2</sub> mixes with air, disperses, and decreases CO<sub>2</sub> storage on sunrise (Stull, 20012).

This section has been added to the revised manuscript.

Figure quality needs general improvement. Larger fonts, particularly in Figures 5-7 is needed.

- Thank you for the suggestion. The figure quality has been improved in the revised manuscript, and larger fonts have been applied, particularly in Figures 5-7, to enhance readability.