Author's Response to the editor's comments on **"Monitoring and modeling seasonally varying anthropogenic and biogenic *CO*2 over a large tropical metropolitan area"**.

First, we would like to thank the editor for their valuable comments related to the manuscript "**Monitoring and modeling seasonally varying anthropogenic and biogenic *CO*2 over a large tropical metropolitan area**" by Rafaela Cruz Alves Alberti et al. Your valuable feedback has helped us identify areas for improvement and refine the manuscript accordingly. The editor's comments are written in black, while our author's comments are in **blue**. Modifications from the manuscript are in cyan and *italic*.

Main: 1. Some explanations in the results section are not entirely correct or convincing.

• Line 219-220, Line 228: The description is inconsistent and could easily lead to misunderstanding. Line 219 mentions that summer is "less intense in the Atlantic Forest," while Line 228 states "negative net fluxes in February, particularly in the Atlantic Forest." These statements seem contradictory.

Indeed, we agree that these lines could lead to a misunderstanding regarding the Atlantic Forest results. We have clarified the apparent inconsistency between lines 219 and 228 by explicitly distinguishing the spatially averaged behavior of the Atlantic Forest biome across the domain (panel a) from the point-based simulation results (panel b). The revised paragraph now clarifies that. While the Atlantic Forest as a whole shows heterogeneous behavior in February with both CO2 sinks and sources, the flux tower site shown in panel b is located in the northeastern portion of the ecosystem, where net CO2 uptake was observed. These changes were made to ensure that readers can clearly understand the results at both the ecosystem and site-specific levels.

"*During the summer, ecosystem productivity is expected to peak across all land cover classes, typically resulting in negative NEE. This behavior was clearly observed in February (Figure 4a) for Cerrado, sugarcane, and pasture areas. In contrast, the Atlantic Forest in the southwestern portion of the domain exhibited positive NEE values, an unexpected pattern for a summer month. This may be linked to a combination of structural and anthropogenic factors, as well as limitations of the model itself. The Atlantic Forest is marked by structural heterogeneity, extreme biodiversity, and high fragmentation, which can lead to significant local variation in CO2 fluxes. In addition, the SEEG (2021) report highlights a progressive decline in the biome's carbon sink function. Model limitations also likely contribute to these discrepancies, particularly simplifications in VPRM's equations of respiration and phenology, which may not fully capture the complex dynamics of ecosystems like the Atlantic Forest (Rezende et al., 2018; Segura-Barrero et al., 2025).*"

• Figure 4b and 4c: Why does Figure 4b show the Atlantic Forest as red (positive), while in Figure 4c, the site clearly shows significant negative values during the day, which exceed the positive values at night? If the monthly average of the NEE from Figure 4c is calculated, would it still be positive as shown in Figure 4b?

We appreciate the opportunity to clarify this point by providing the monthly mean NEE values for each flux tower site represented in Figure 4c. For August, the monthly average NEE values were the Atlantic Forest is 1.55 µmol m-2 s-1, the cerrado 0.55 µmol m-2 s-1, and the sugarcane 3.00 µmol m-2 s-1. Although Figure 4c shows pronounced negative fluxes during the daytime for the Atlantic Forest site, the nighttime positive fluxes are more consistent and frequent throughout the month. As a result, the monthly NEE is positive, which is consistent with the light red shading shown in Figure 4b. This same behavior is observed to varying degrees in the other ecosystems as well.

• Line 268-269: The small absolute value of the PDJ observation-simulation bias is due to the small CO_2 signal at this site. If the goal is to discuss or compare the simulation performance with the IAG

site, a more reasonable approach would be to look at the relative error, e.g., signal-to-bias, rather than directly concluding that "model predictions are more accurate at PDJ."

In response, we have revised the paragraph to avoid making direct claims about model performance at PDJ based solely on the magnitude of the absolute bias. Instead, we emphasize that the PDJ site exhibited low biases and lower variability between model and observationsand, which attribute this to PDJ site characteristics, its higher elevation, dense vegetation cover, and reduced influence from urban emissions. These factors contribute to a lower CO2 signal and a more straightforward representation of seasonal trends, which likely explains the smaller bias. Now the paragraph reads:

"The PDJ station exhibited low positive biases and smaller standard deviations between the model and observations. Its higher elevation and dense vegetation cover simplify the representation of seasonal trends, reducing the influence of urban emissions and resulting in lower CO2 concentrations at this site (see Figure B7 in Appendix B)."

• Section 3.3.1: Line 271-277: As far as I know, in WRF-Chem, background, anthropogenic, and biogenic emissions are three separate variables (CO2_BCK, CO2_ANT, CO2_BIO) in the output netcdf files. The authors can simply display them individually or sum them to achieve the desired result, without the need to rerun simulations with different "emission scenarios" as stated. Did the authors modify some part of the model that requires resimulation?

While it is true that WRF-Chem (WRF-GHG configurations) can provide separate CO2 variables such as CO2_BCK, CO2_ANT, and CO2_BIO, in our study, the VPRM model was used in offline mode, not coupled with WRF-Chem. As a result, the separation of flux components was not available within a single simulation, since the biogenic and anthropogenic fluxes were already combined (summed) in a single input file. To analyze the contribution of each component separately, we performed additional simulations using the same model configuration but different emission input files: one containing both anthropogenic and biogenic fluxes (as originally used), and others including only one component at a time. No changes were made to the model configuration; only the input files were varied between scenarios.

• Line 346 and Figure 7h: The authors say, "This highlights the role of both biogenic and meteorological processes in shaping CO_2 variability at this site," but from Figure 7h, the increments for biogenic and anthropogenic emissions appear to be similar, and it seems that the increase is due to the rise in background concentrations. How does this align with the authors' statement?

Indeed, we agree with your observation that the increase in CO2 concentrations at the PDJ site in late August is primarily associated with rising background concentrations, as shown in Figure 7h. This pattern was also observed at the IAG site (Figure 7f), indicating that the background signal played an important role at both locations during this period.
Additionally, we acknowledge that the original sentence "*This highlights the role of both biogenic and meteorological processes in shaping CO2 variability at this site*" may have led to some confusion, as it seemed to refer specifically to the end of the month. In fact, our intention was to highlight the overall behavior at the PDJ site throughout the entire period, not just the final days of August. To address this, we have revised the sentence to clarify this:

"... Regarding the source contributions, the model simulation aligned with the observed temporal profile, displaying a more pronounced biogenic signal than at the IAG site, which further emphasizes the significant role of vegetation as a source of CO2 emissions at this location.(Figure 7h). Before late August, observed values tended to be higher than the simulations, whereas in the final days of the month, the model overestimated CO2 concentrations. This overestimation is associated with an increase in background concentrations, a pattern also observed at the IAG site during the same period."

• Section 3.3.2, in Line 361-363: Actually, I believe the analysis in Lines 349-363 is meaningless, especially the conclusions in Lines 361-363. When comparing observations and simulations, of course, the simulation values should consider anthropogenic, biogenic, and background emissions together, as this more closely reflects real-world conditions. Isn't this something that should be done? It's common sense. Why conduct so much analysis just to conclude that "simulating with only one factor leads to larger discrepancies with observations, while considering all three factors improves simulation performance"? If the authors' goal is to analyze the individual contributions of the three factors, then Figures 6 and 7 already serve that purpose.

We agree that, from a modeling standpoint, it is indeed expected that simulations incorporating anthropogenic, biogenic, and background contributions would yield the best agreement with observed CO2 concentrations. However, our intention in that section was not to restate an obvious conclusion, but rather to provide a quantitative assessment of how each emission component, used in isolation or in combination, affects model performance in our specific study region. To clarify this and avoid general or redundant conclusions, we revised the paragraph to focus solely on presenting the bias and RMSE values for each scenario, allowing for a more objective comparison of model performance.

We rewrote the paragraph to: *"The bias and RMSE for each simulation at the IAG and PDJ sites for February and August 2019 are illustrated (see Figure B7 in Appendix B). At IAG, the average bias ranged from -14.31 to -9.17 ppm, while at PDJ it ranged from -3.54 to -0.96 ppm. RMSE values were consistently higher at IAG, exceeding 20 ppm in most scenarios, while PDJ showed lower errors, generally below 12 ppm."*

• Line 371-372: Figure B4 shows that the evening rush hour for traffic occurs before 19:00, not after. How do the authors explain this?

Indeed, this can not attribute a evening rush hour traffic. To correct this, we removed this affirmation in the sentence. Now it is read:

In Figure 8, both bar graphs of the hourly correlation between CO2 and CO concentrations show values above 0.5 for observed CO2 and above 0.25 for simulated CO2 during the early hours of the day (until 10h) and again in the evening (after 19h).

2. There are several discrepancies between the textual analysis and the figures, with several obvious errors.

• Line 264: The simulated PDJ values are higher than the observed values. Why do the authors say "underestimated vehicular emissions in these areas"?

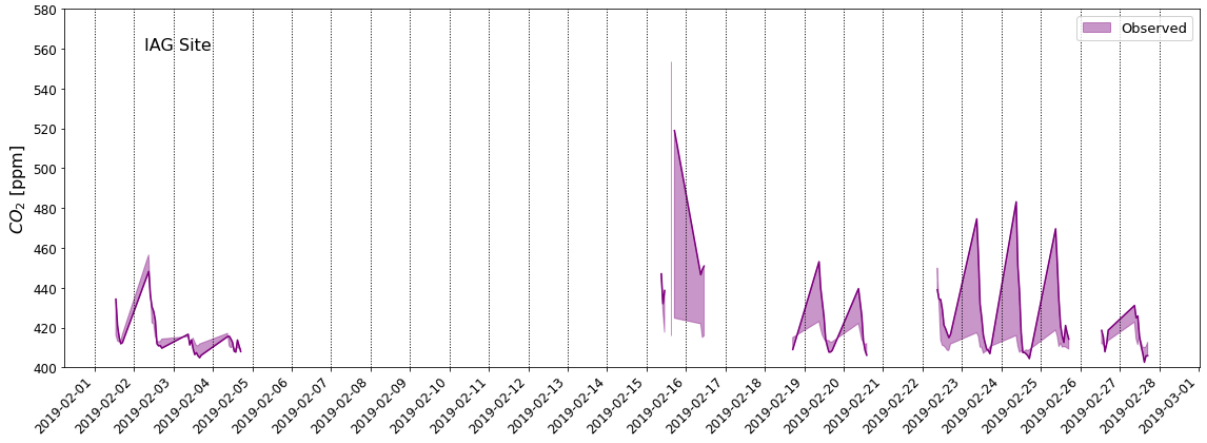
It seems there has been a mistake in writing. Instead, it should be written:

"... likely stems from model limitations, including grid resolution and insufficient representation of localized characteristics at different sites."

• Line 328 and Figure 7a: From Figure 7a, it appears that the IAG site has no observation data for February 21 and 22!

We carefully reviewed the dataset and the corresponding figure. There is, in fact, observational data available for both February 21 and 22. However, due to temporal gaps, particularly on February 21st, this data was partially excluded during postprocessing. Specifically, our filtering step considered only data between 09:00 and 17:00 local time to ensure consistency in daily comparisons. On February 21st, data was only available during nighttime hours, and thus it was excluded from the analysis. In contrast, on February 22nd, there was sufficient daytime data

and which is therefore represented in Figure 7a. To clarify this, you can see in the figure below only the observed CO2 data used in Figure 7a. This provides a clearer view of the data gaps and supports our explanation.



Additionally, we revised the sentence in the manuscript to avoid misinterpretation and to correct the statement regarding February 21. The updated sentence now reads:

"...Furthermore, on February 2nd and 22nd, observed CO2 peaks were captured by the model with similar magnitude only when both anthropogenic and biogenic emissions were included."

• Line 322 and Line 339: The IAG site has a model-to-observation difference of 8 ppm in February (Line 322) and 13 ppm in August (Line 339). The error in August is larger than that in February. Why do the authors say in Line 339 "only 13 ppm, i.e., a closer approximation compared to February"?

Indeed. This is a wrong statement. This sentence is now:

"...resulting in a discrepancy of 13 ppm, i.e., a higher difference compared to February."

• Line 341-342: observation is 412 ppm, model is 412 ppm in the text. Why do the authors say that the observation is surpassing the simulation?

The original statement referred to a small decimal difference between the observed and simulated monthly averages (observed: 412.75 ppm; simulated: 412.15 ppm). However, since these decimal values were not presented in the text, the wording has led to confusion. To avoid misinterpretation, we have revised the sentence in the manuscript to:

"...the monthly average concentration observed and simulated were 412 ppm. While the model slightly underestimated some days in the month and overestimated others, it generally captured the observed variability."

• Line 351-352: This is a clear mistake! It should be February, not August. Also, it's not Figure 7c, and it should be a positive bias, not a negative bias.

Indeed. This paragraph was rewritten due to the previous review comment.

"The bias and RMSE for each simulation at the IAG and PDJ sites for February and August 2019 are illustrated (see Figure B7 in Appendix B). At IAG, the average bias ranged from -14.31 to -9.17 ppm, while at PDJ it ranged from -3.54 to -0.96 ppm. RMSE values were consistently higher at IAG, exceeding 20 ppm in most scenarios, while PDJ showed lower errors, generally below 12 ppm."

• Line 356-357: clear mistake! Figure B7 shows that the PDJ for only Anthropogenic emissions does not have the poorest RMSE.

Same as the previous comment. This paragraph was rewritten due to the previous review comment.

"The bias and RMSE for each simulation at the IAG and PDJ sites for February and August 2019 are illustrated (see Figure B7 in Appendix B). At IAG, the average bias ranged from -14.31 to -9.17 ppm, while at PDJ it ranged from -3.54 to -0.96 ppm. RMSE values were consistently higher at IAG, exceeding 20 ppm in most scenarios, while PDJ showed lower errors, generally below 12 ppm."

• Line 358: clear mistake! Figure B7 shows that IAG with anthropogenic sources in August does not have the highest RMSE.

Same as the previous comment. This paragraph was rewritten due to the previous review comment.

"The bias and RMSE for each simulation at the IAG and PDJ sites for February and August 2019 are illustrated (see Figure B7 in Appendix B). At IAG, the average bias ranged from -14.31 to -9.17 ppm, while at PDJ it ranged from -3.54 to -0.96 ppm. RMSE values were consistently higher at IAG, exceeding 20 ppm in most scenarios, while PDJ showed lower errors, generally below 12 ppm."

3. Many sentences throughout the manuscript are redundant or have syntax errors. I recommend that the authors read through the entire text and remove redundant sentences. Please see some examples bellows:

• Line 44-47: "Coupled VPRM" and "integrated VEIN" are parallel in structure, but the sentence is too long. The intended meaning is that the VEIN model is integrated into the VPRM model. I suggest rewriting the sentence for clarity.

We have rewritten the paragraph to improve clarity and have also included additional information regarding the specific sectors considered from the EDGAR inventory, which was not previously mentioned in the manuscript.

"This study aims to address these gaps by conducting a comprehensive analysis of anthropogenic and biospheric CO2 dynamics near the MASP. To achieve this, we employed the Weather Research and Forecasting model with Chemistry (WRF-Chem), offline coupled with the Vegetation Photosynthesis and Respiration Model (VPRM) (Mahadevan et al., 2008). Vehicular emissions were incorporated using the VEIN model (Ibarra-Espinosa et al., 2018), while emissions from the industrial, energy, residential, and refinery sectors were derived from the EDGAR inventory. This integrated modeling framework enables a detailed assessment of the main drivers of CO2 variability in the region."

• Line 67-70: You can directly state "CO_2 initial and boundary conditions" instead of repeating it twice "initial and boundary conditions" in the sentence. General Additionally, I recommend using "CO_2" instead of "chemical," also change it in Table 1.

We have revised the paragraph to avoid the repetition of "initial and boundary conditions" and to improve readability by breaking down long sentences. Additionally, we replaced the term "chemical" with "CO2" in Table 1, as suggested.

"The meteorological conditions used to drive the simulations were obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 reanalysis dataset, with a horizontal resolution of 0.25° × 0.25° and 6-hourly intervals (Hersbach, 2016). For CO_2, initial and boundary conditions were provided by Carbon Tracker, which offers data at a horizontal resolution of 3° in longitude and 2° in latitude, with 25 vertical layers (http://carbontracker.noaa.gov)."

• Line 83-84: "EDGAR lacks temporal variability" and "inventory does not provide hourly profile" are repetitive.

We revised the sentence to:

"However, as the EDGAR inventory does not provide hourly emission profiles, its emissions were assumed constant throughout the day (Fig. B2 in Appendix B)."

• Line 87: "as a flux input" and "as input data" are repetitive.

We have revised the sentence to eliminate the redundancy. The updated sentence now reads:

"Biogenic CO2 fluxes were simulated offline using the VPRM model (Mahadevan et al., 2008) and incorporated as flux input data in the WRF-Chem simulations."

• Line 171-172: syntax errors, incomplete sentence.

We have corrected the grammatical inconsistency. The revised version reads:

"To evaluate the model performance, we calculated the bias, RMSE, and R^2, with the corresponding equations provided in Appendix A."

• Line 251-252: The term "PDJ" appears twice in the same sentence, making it redundant.

We have revised the sentence to remove the redundancy.

"Additionally, lower CO2 concentrations were expected at PDJ during the summer due to the stronger vegetation signal compared to the IAG site."

• Line 267-268: The expression is redundant, as the parts before and after "and" convey the same meaning.

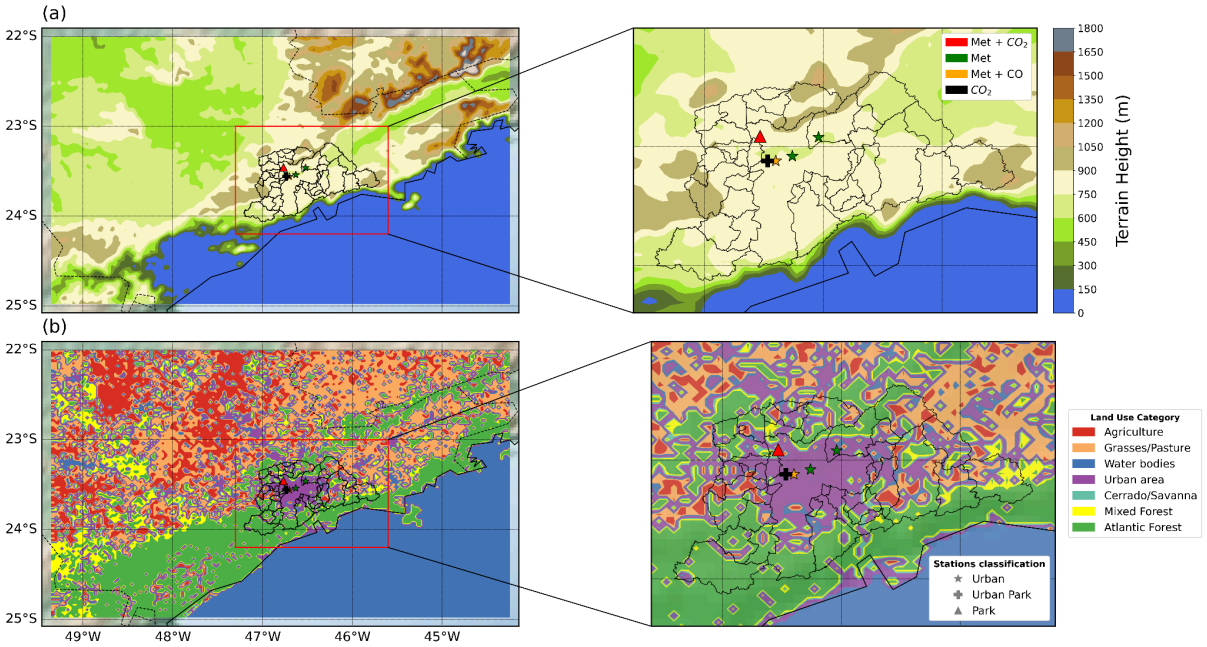
We have written the sentence to remove the redundancy and enhance its clarity. The revised version is:

"The PDJ station exhibited low positive biases, indicating better agreement and lower errors between the model and observations across all periods. The higher elevation and vegetation cover at PDJ simplify seasonal trend modeling, reducing the impact of urban factors and enhancing model performance (see Figure B7 in Appendix B)."

4. The quality and color of the figures are not visually easy to get information:

• The color scheme in Figure 1 is not visually appealing and makes it difficult to identify the stations. Additionally, I recommend using (a), (b), etc., instead of referring to "first panel" and "second panel" to improve clarity. Similarly, see Line 278 to avoid unclear descriptions.

We revised Figure 1 by updating the color scheme to improve visual contrast among land-use categories and to make the station locations more distinguishable. Additionally, we labeled the panels as (a) and (b) and updated both the figure caption to replace vague descriptions like "first panel" or "second panel," as suggested.



"Figure 1. Panel (a) shows the terrain height and urban boundaries of the MASP region within the WRF-Chem model domain (D01). Station classifications are indicated using different symbols: Urban (★), Urban Park (✚), and Park (▲). Panel (b) presents the land use category map for the same domain (D01), which was used by the VPRM model to calculate CO2 fluxes. The colors of the station markers represent the type of measurements conducted at each location: red indicates stations measuring both meteorological variables (Met) and CO2 concentrations; green indicates stations measuring only Met; dark yellow denotes stations measuring both Met and CO concentrations; and black indicates stations measuring only CO2 concentrations. The IAG station is marked as (✚), the PDJ station is (▲), Pinheiros station is (★), Guarulhos and Parque D.Pedro II are (★)."

• Why are the figure numbers in the supplementary material not assigned in the order in which they appear in the manuscript?

Thank you for pointing this out. We have reordered the supplementary figures to match the order in which they are cited in the manuscript, ensuring better clarity and consistency for the reader, and also updated in the text. Below you can see the new ordered in appendix B:

Figure B1. Vehicular CO2 emissions over the study domain (D01). (a) Spatial distribution of average daily CO2 emissions from vehicles for August 2019, as estimated by the VEIN model. (b) Total monthly vehicular CO2 emissions from February to August 2019 over domain D01. (c) Diurnal profile of vehicular CO2 emissions at the IAG site during August 2019.

Figure B2. CO2 emissions from energy, residential, refineries and industry sectors by the EDGAR inventory over the study domain (D01). (a) Spatial distribution of average daily CO2 emissions in August 2019. (b) Monthly total CO2 emissions from February to August 2019 over domain D01.

Figure B3. Average daily anthropogenic CO2 emissions (in tons) for August 2019 within the simulated domain, disaggregated by sector. Bars represent the mean daily emissions per sector, while percentages indicate each sector's relative contribution to total anthropogenic emissions.

Figure B4. The panels in a) show the scatter plots of hourly measurements of 2 m air temperature (T2m) and b) show 10 m wind speed (WS) compared to observed data from the Parque D.Pedro II station. The figure illustrates the relationship between modeled and observed data. The panels in c) show the daily averages from February to August 2019 of 2 m air temperature (T2m), 10 m wind speed (WS), and wind direction (WD). Black line represents the observed data and red line represents the model simulation.

Figure B5. The same as B4 for Guarulhos.

Figure B6. The same as B4 for Pinheiros.

Figure B7. Diurnal cycle of in situ CO2 concentration and planetary boundary layer (PBL) height for the entire simulated period. The black line represents the median hourly concentrations from WRF-Chem, while the purple line corresponds to the observed values. The shaded areas indicate the interquartile ranges. Panel a) shows the observed and simulated surface CO2 concentration at the IAG site; b) the simulated PBL height at the IAG site; c) the observed and simulated surface CO2 concentration at the PDJ site; and d) the simulated PBL height at the PDJ site.

*Figure B8. Bias (ppm) and RMSE (ppm) for each simulation at the surface CO2 observation sites. Panels (a) and (b) represent the simulations for February, while panels (c) and (d) represent the simulations for August (ALL_*: black, ANTH_*: red, VPRM_*: green) *Represents the observation sites, e.g. IAG and PDJ.*

Figure B9. Time series of smoothed column concentrations observed (black) and modeled (red) for the period from 1 April 2019 to 31 August 2019.

• Line 213 and Figure 4c: Figure 4c shows hourly data, not daily data, right?

Indeed, Figure 4c presents hourly variation, not daily data. We have corrected this in the text and also revised the figure caption to reflect the content accurately.

"…The first panel in Figure 4 shows the monthly net CO2 flux simulated by the VPRM model for 2019.February represents a summer month, while August represents a winter month. The second panel shows the monthly hourly net CO2 flux simulated at the three flux tower sites used to optimize the VPRM model parameters"

Figure 4. The first panel shows the monthly mean of net ecosystem exchange (NEE) (mol km−2 h −1) for February (a) and August (b) 2019. The second panel (c) presents the hourly variability of NEE (µmol m−2 s −1) for the same months (February and August) at three different PFTs: Atlantic Forest, Cerrado/Savanna, and Sugarcane.

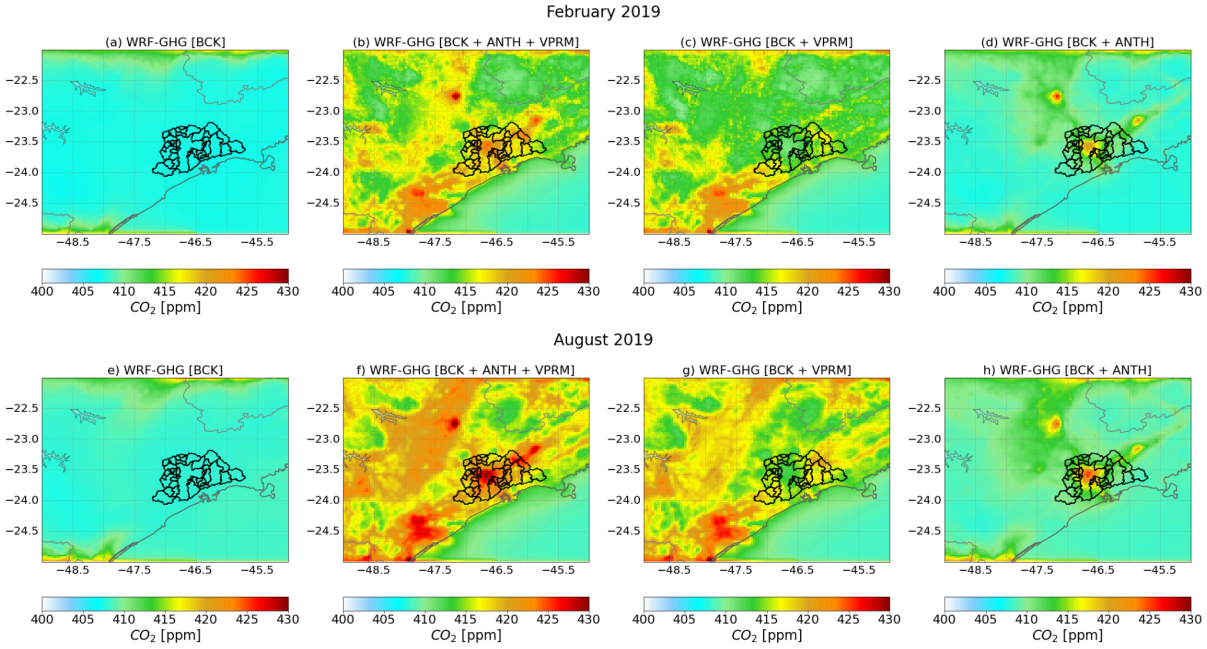
• Figure 4a: Figure 4a shows the monthly mean NEE, not the "monthly mean diurnal cycle" as stated in the caption. How can the diurnal cycle be observed from Figure 4a?

Thank you for this correction. Figure 4a shows the monthly mean NEE, not the monthly mean diurnal cycle. This was a typo in the figure caption, while the description in the main text was already correct. We have corrected the caption in Figure 4 to reflect this.

Figure 4. The first panel shows the monthly mean of net ecosystem exchange (NEE) (mol km−2 h −1) for February (a) and August (b) 2019. The second panel (c) presents the hourly variability of NEE (µmol m−2 s −1) for the same months (February and August) at three different PFTs: Atlantic Forest, Cerrado/Savanna, and Sugarcane.

• Figure 6: Why use a discrete colorbar instead of a continuous one? This makes it difficult to distinguish values like 6 ppm in Line 280 and 8 ppm in Line 295. Based on the current colorbar, one could also interpret the value as 4 ppm, right?

In response to this suggestion, we revised Figure 6 by replacing the discrete colorbar with a continuous one. Additionally, we improved the font sizes for better readability and included latitude and longitude gridlines to enhance spatial reference. These changes help clarify the CO2 concentration gradients across the domain and make the increases more visually evident.



• Figure B4 and B5: Please include the latitude and longitude. Additionally, there is no need to display different months as it is difficult to discern any significant differences. It would be better to show just one figure of spatial distribution and use other types of charts to present the monthly emission totals. Moreover, the caption for Figure B5 is not accurate, e.g., "daily mean"? which sectors from EDGAR?

We have revised Figures B4 and B5, which are now renumbered as Figures B1 and B2 due to reordering. As suggested by the reviewer, we removed the multiple monthly spatial plots and now present only one representative spatial distribution of average daily CO2 emissions for August 2019. Latitude and longitude ticks have been added. Additionally, monthly total emissions from February to August 2019 are now presented using bar charts. In Figure B1 (VEIN emissions), we included a third panel (c) showing the diurnal profile of vehicular CO2 emissions at the IAG site during August 2019. In Figure B2 (EDGAR emissions), the panels display the spatial distribution of average daily CO2 emissions for August 2019 and the corresponding monthly emissions totals from February to August 2019. We have also clarified in the figure caption that these emissions include combined contributions from the energy, industry, residential, and refinery sectors.

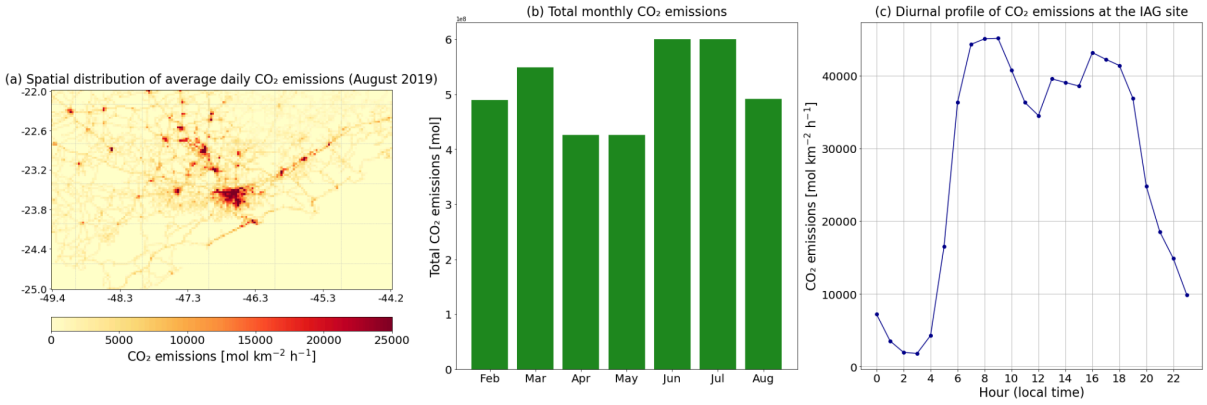


Figure B1. Vehicular CO2 emissions as estimated by the VEIN model over the study domain (D01). The panel (a) represents the spatial distribution of average daily CO2 emissions for August 2019 over D01. Panel (b) represents the total monthly CO2 emissions from February to August 2019 over the D01. Panel (c) shows the diurnal profile of CO2 emissions at the IAG site during August 2019.

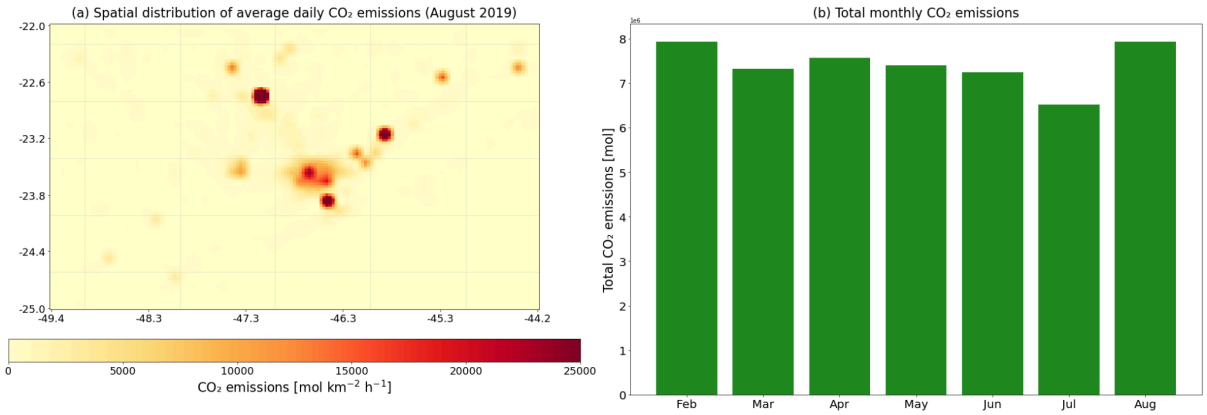


Figure B2. CO2 emissions from energy, residential, refineries, and industry sectors by the EDGAR inventory over the study domain (D01). Panel (a) shows the spatial distribution of average daily CO2 emissions for August 2019 over D01. The panel (b) represents the monthly total CO2 emissions from February to August 2019 over the domain.

• Figure 9: redundant in caption "Daily mean concentrations of CO2 observed concentrations".

We have revised the caption for Figure 9:

"Daily mean concentrations of CO2, both observed (black dashed line) and simulated (purple line), at the IAG site, along with observed CO concentrations (red dotted line) at the Pinheiros site during August 2019."

Additional improvements have been made to Figures 2, 4, 5, and 7, which were revised to enhance axis labels and captions. Similarly, Figures B4, B5, and B6 in Appendix B have been updated to improve the readability of axes, titles, and legends.

Specific:

• Line 48: What does "smoothed" XCO2 mean? How is the XCO_2 from WRF-Chem smoothed?

In the sentence on line 48, "smoothed XCO2" refers to WRF-Chem-simulated column-averaged CO_2 concentrations that were post-processed using the satellite averaging kernels and a priori profiles, as described in Section 2.2.3 of the Methods. This smoothing step ensures that the modeled CO2 is vertically weighted in a manner consistent with the sensitivity of the OCO-2 instrument, allowing for a valid comparison between model output and satellite retrievals. To avoid misunderstanding, we revised the sentence in the manuscript to clarify this.

In addition, we utilized data from the OCO-2 satellite to cover the study domain, comparing WRF-Chem-simulated XCO2 concentrations (considering biogenic and anthropogenic emissions) post-processed using OCO-2 averaging kernels (i.e., smoothed XCO2).

• Section 2.1.1: What is the total anthropogenic emission for the region? Why did the authors only consider emissions from vehicles, energy, and industry? What about other emission sources in the region? What are the proportions of emissions from different anthropogenic sources?

We have revised the paragraph in Section 2.1.1 to enhance clarity and precision. In response to your question regarding the scope and total of anthropogenic emissions, we have updated the section to explicitly state that, in addition to vehicular sources (from VEIN), our analysis

includes emissions from the energy, industry, residential, and refinery sectors based on the EDGAR inventory.

To further address the proportions of these emissions, we have added a figure (Figure B3 in Appendix B) that illustrates the average daily anthropogenic CO2 emissions in August 2019 for the MASP. According to this analysis, vehicular emissions represent 76.1% of the total anthropogenic CO2, followed by industry (10.0%), refineries (7.6%), residential (3.8%), and energy (2.5%) sectors.

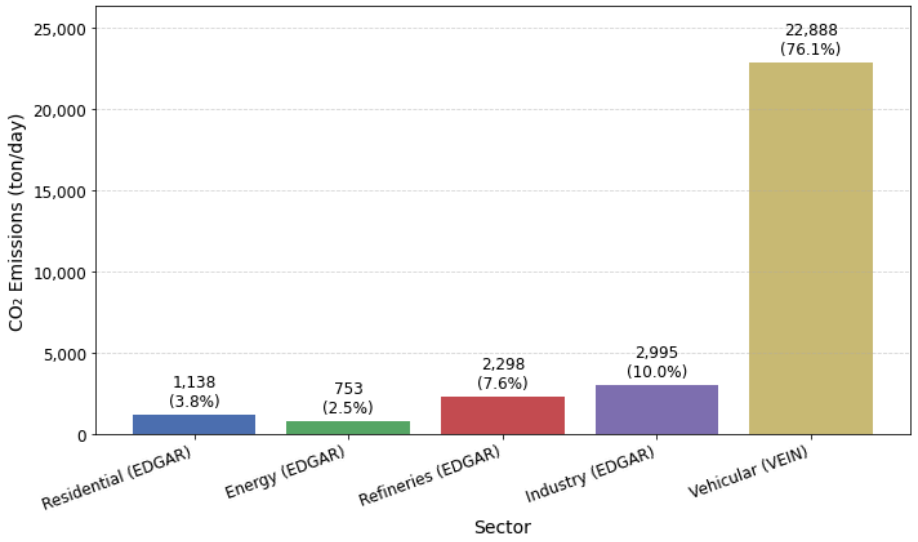


Figure B3. Average daily anthropogenic CO2 emissions (in tons) for August 2019 within the simulated domain, disaggregated by sector. Bars represent the mean daily emissions per sector, while percentages indicate each sector's relative contribution to total anthropogenic emissions.

• Line 80: No need to use "In contrast".

The expression "In contrast" was removed, as it was unnecessary in that context.

• Line 83: What are "interpolation techniques" that were used from 0.1° to 3km? Based on Figure B5, it appears to be bilinear interpolation?

We also clarified that bilinear interpolation was used to regrid the EDGAR emissions from the original 0.1° × 0.1° resolution to the 3 km spatial resolution required by WRF-Chem. Thank you for these observations. In response, we revised the paragraph in Section 2.1.1 to improve clarity and address the concerns raised.

"...EDGAR provides global annual emissions at 0.1° × 0.1° spatial resolution, which we regridded to 3 km using bilinear interpolation to match the WRF-Chem model domain. Because EDGAR does not provide hourly temporal profiles, these emissions were assumed constant over the day (Fig. B2 in Appendix B). To evaluate the relative contribution of each sector to total emissions in the region, Figure B3 (Appendix B) presents the mean daily CO2 emissions in August 2019. Transport emissions (VEIN) represented the dominant share, accounting for 76.1%, followed by industry (10.0%), refineries (7.6%), residential (3.8%), and energy (2.5%) sectors."

• Line 119: "surface model evaluation" is not accurate and could lead to ambiguity. Please rephrase the sentence.

We agree that the original expression "surface model evaluation" could lead to ambiguity. To improve clarity, we revised the sentence to:

"We assessed near-surface model performance using CO2 observations from the METROCLIMA network in São Paulo (see Table 3 and Figure 1), the first conventional in situ greenhouse gas measurement network established in South America (www.metroclima.iag.usp.br)."

• Line 138: typo "January to 2015", delete "to".

Done.

• Line 240: It is the location of the site that has an impact, not only the latitude of the observation site.

Thank you for your comment. We agree that the latitude was not the correct word to use in this context. To improve clarity and accuracy, we revised the sentence to emphasize the influence of the site's geographical location.

"This variation in CO2 levels is primarily influenced by the geographical location of the observation site, as well as meteorological conditions such as wind speed and atmospheric stability, and seasonal patterns of photosynthesis and vehicular traffic (see Fig. B4 in Appendix B)."

• Line 256-260, Line 321-322: The current description, such as "this figure was somewhat compromised", makes it difficult to understand how the observations and simulations are being compared. Were missing values removed during the comparison?

We agree that the phrasing was unclear and revised the text to better explain the comparison between observed and simulated data. Specifically, we clarified that missing values in the observational dataset were removed before calculating the monthly mean. The revised text avoids vague expressions and more clearly states how the comparison was made.

"In Figure 7a, which represents only one summer month with available observational data (February 2019), the model generally underestimated CO2 concentrations. The observed average was 424.0 ppm, while the simulated average was 416.0 ppm, an underestimation of approximately 8 ppm. This difference may be partially attributed to the presence of data gaps in the observational data for this site, as only available values were considered when calculating the monthly mean."

• Line 301-302: This sentence does not contribute to the analysis and explanation in the manuscript since the authors only used EDGAR's energy and industry emissions, without incorporating urban area emissions.

Thank you for the comment. However, we would like to clarify that, in addition to the energy and industry sectors, we also incorporated emissions from the residential and refinery sectors from EDGAR inventory, all of which include sources within urban areas.

• Line 312: I mentioned last time that 09-17h local is not only mid-afternoon but daytime. The author replied and made changes, but did not.

We corrected them in section 3.3.2.

• Line 332: suggest change "for the study period" to "in February" to improve clarity.

Thank you for the suggestion, and we incorporated it.

• Line 334: it should be "at PDJ", not "in PDJ".

Done.

• Section 3.3.3: Why does the XCO_2 data for February and March not included in the analysis?

We did not include XCO2 data for February and March in the analysis because there were no valid OCO-2 observations available over the study domain for those months.

• Line 341: add “observed” to “the monthly average concentration stood at 412 ppm” to improve clarity.

This sentence had already been revised in response to a previous comment to address clarity regarding the observed and simulated values. The updated sentence now reads: *“In contrast, for PDJ (Figure 7g), both the observed and simulated monthly average concentrations were 412 ppm.”* **Which explicitly states that the 412 ppm refers to the observed concentration, as well as the simulated one.**

• Line 347-348: This sentence appears suddenly. When the authors say "Figure 4 illustrates more positive CO_2 fluxes". They compare the "more" to what?

We decided to remove it, as it did not contribute meaningfully to the analysis or improve the interpretation of the results.

• Line 401: it should be “Figure 10b and 10c”, not “Figure 10b”.

Done.

• Proper nouns should be written in full with their abbreviations in parentheses when they first appear. After that, only the abbreviation should be used throughout the rest of the manuscript. This issue appears multiple times in the manuscript. For example: a) "MASP" in Line 4, Line 32, and Line 72. b) "VPRM" in Line 7, Line 45, and Line 86. c) "WRF-Chem" in Line 4, Line 44, and Line 57. General d) "VEIN" should first appear in Line 46 instead of Line 73.

I recommend that the authors standardize the use of abbreviations accordingly.

We have reviewed the manuscript and corrected the errors pointed out by the reviewer.

• Line 5 and Line 59: Letter case for METROCLIMA or Metroclima.

Done.

• The letter "F" in "Atlantic Forest" is sometimes capitalized and sometimes lowercase in the manuscript. Please ensure consistent capitalization throughout the text.

Done.