Title: Observed Impacts of Aerosol Regimes on Energy and Carbon Fluxes in the Amazon Forest

Response (blue color) to anonymous Referee #2 (black). The original manuscript was changed accordingly. The lines indicated in our answers correspond to the track version of the manuscript.

General comments

The work uses observations of AOD to evaluate impacts of aerosols on amazon forest energy balance fluxes at unique data set from a relatively new flux site in Manaus.

We would like to thank Referee #2 for their attention to detail and helpful comments, which have contributed to the improvement of the manuscript.

First of all we would like to begin our responses by stating that in the new version of the manuscript, we regrouped our data in a way that allowed us to include a greater number of runs (half-hour periods). In the previous version of the manuscript, in addition to excluding all periods when clouds were present, which is very common in the Amazon, we also excluded all data from a given day and time when a variable was missing. For example, if we did not have the reflected shortwave radiation measurement for a given time, we removed all other variables for that same time. This resulted in only 523 valid half-hour periods (370 dry season, 153 wet). In the new version of the Manuscript, we decided to regroup the variables so that they did not depend on each other. We first identified the periods in which we had the Clean and Polluted regimes and then identified how many runs of each variable were available for each regime. After this procedure, the number of runs increased substantially, as shown in Table R1, comparison between the dataset used in the first version of the manuscript (single database) and the dataset used for this new version (database by variable).

Table R1: Number of runs (half-hour periods) after all quality controls mentioned in section 2.2.

Variables	Single database					Database by variable				
	10:00 -14:00 LT		07:00 -17:00 LT		Total	10:00 -14:00 LT		07:00 -17:00 LT		Total
	No. Clean	No. Polluted	No. Clean	No. Polluted	No. Sample	No. Clean	No. Polluted	No. Clean	No. Polluted	No. Sample
SWin(Wm^{-2})	98	81	219	151	370	301	204	736	459	1195
SWout(Wm^{-2})	98	81	219	151	370	301	204	736	459	1195
LWatm(Wm^{-2})	98	81	219	151	370	301	200	733	453	1186
LWterr(Wm^{-2})	98	81	219	151	370	301	204	735	459	1194
Rn(Wm^{-2})	98	81	219	151	370	301	200	733	453	1186
H(Wm^{-2})	98	81	219	151	370	197	192	455	389	844
LE(Wm^{-2})	98	81	219	151	370	183	180	447	386	833
FCO_2($\mu molm^{-2}s^{-1}$)	98	81	219	151	370	247	195	596	405	1001
G(Wm^{-2})	98	81	219	151	370	301	218	741	487	1228

Specific comments

The work is highly relevant, and the data used is state of the art. However, most of the analysis is done with output from a model rather than with the 30 min H and LE observed fluxes (Figs 4-6). Justification for this approach was not 100% clear and there is no mention of how good the models are at representing the observations and what is the uncertainty related to the results inferred from such simulations. Why is not better to use the data?

We thank the reviewer #2 for their comment. We clarify that all analyses in this study were based on the measured data. The polynomial fit shown in Figs. 4-6 (Fig. 5-7 in the new version of the manuscript) was applied solely as a smoothing technique for visualization purposes. In the revised manuscript, we have included the 30-min observed data points in the figures to better illustrate data variability. This clarification has been incorporated into the manuscript as follows:

L139-141: "*To improve the visualization of the mean diurnal patterns, a 4th-order polynomial curve was applied exclusively as a smoothing technique to the observational data. This curve fitting was used solely for graphical purposes and does not represent a physical or predictive model. All analyses were based on the measured data.*"

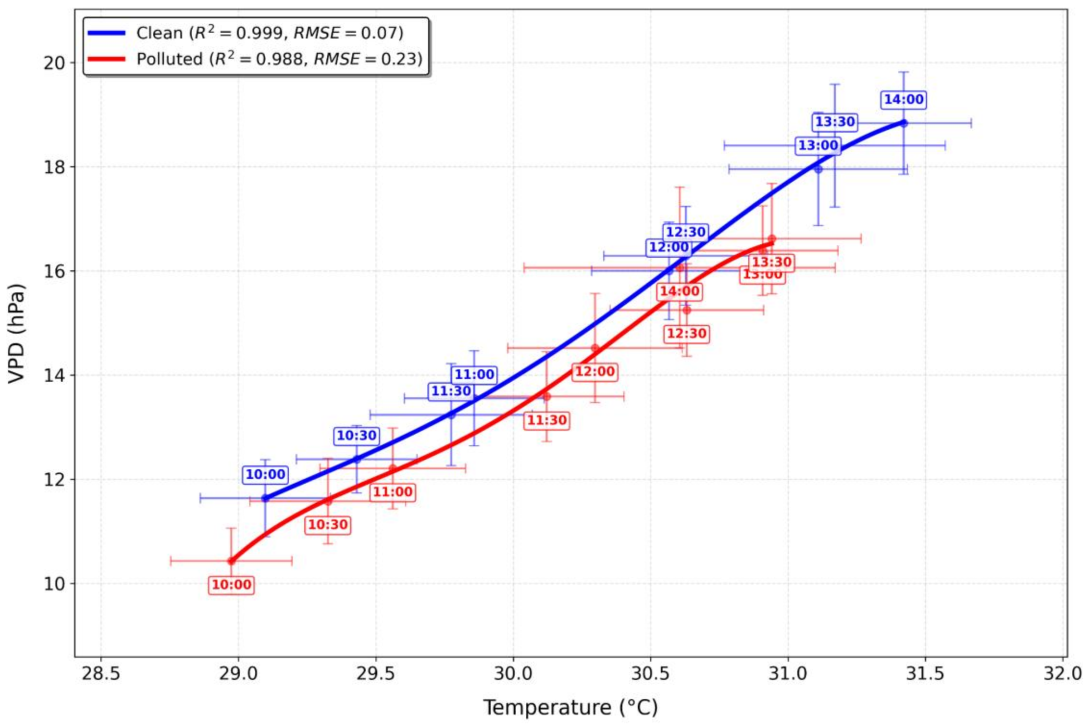

Figure R1. Relationship between temperature and vapor pressure deficit (VPD) above the forest canopy at the ATTO site for Clean and Polluted regimes during the dry season (2016–2022) (Figure 5 in the new version of the manuscript).

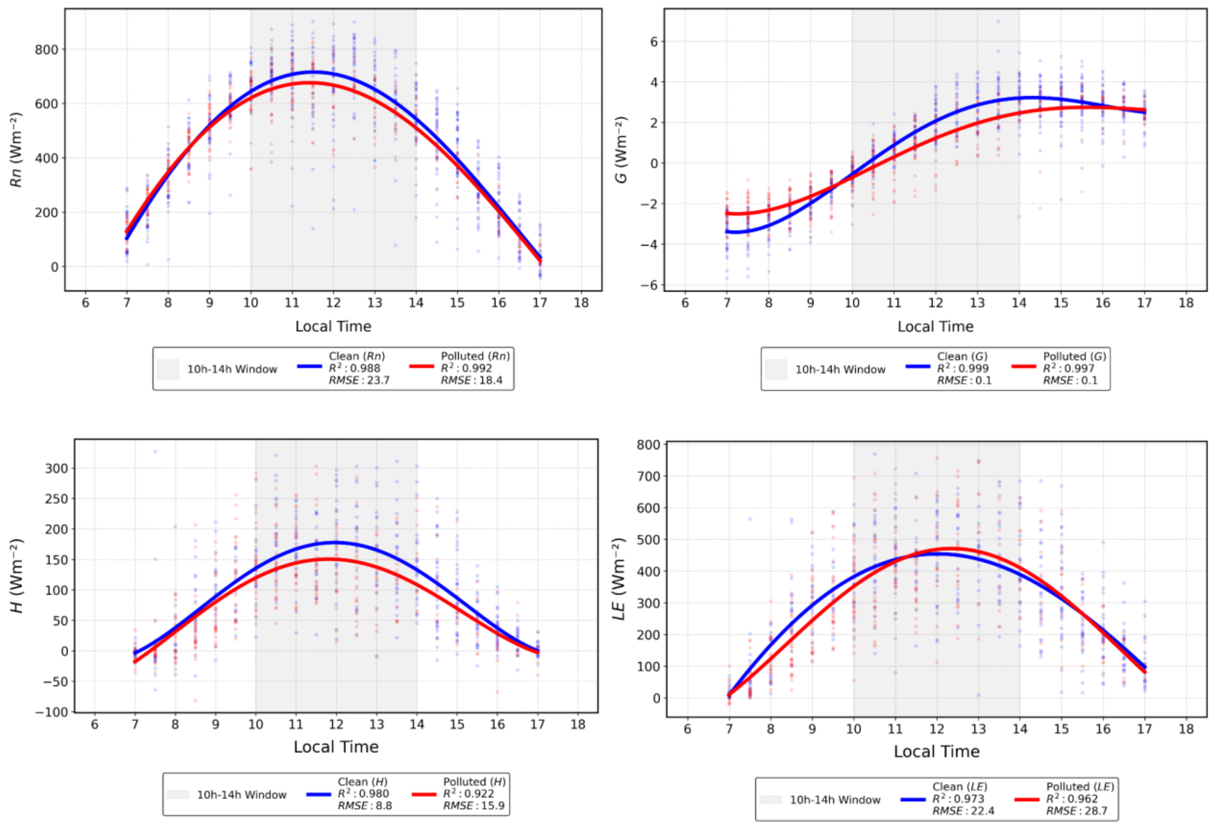

Figure R2. Diurnal cycle of surface fluxes during the dry season (2016–2022) under Clean (blue) and Polluted (red) regimes, highlighting the 10:00–14:00 LT period. Rn (net radiation), G (ground heat flux), H (sensible heat flux), and LE (latent heat flux). (Figure 6 in the new version of the manuscript).

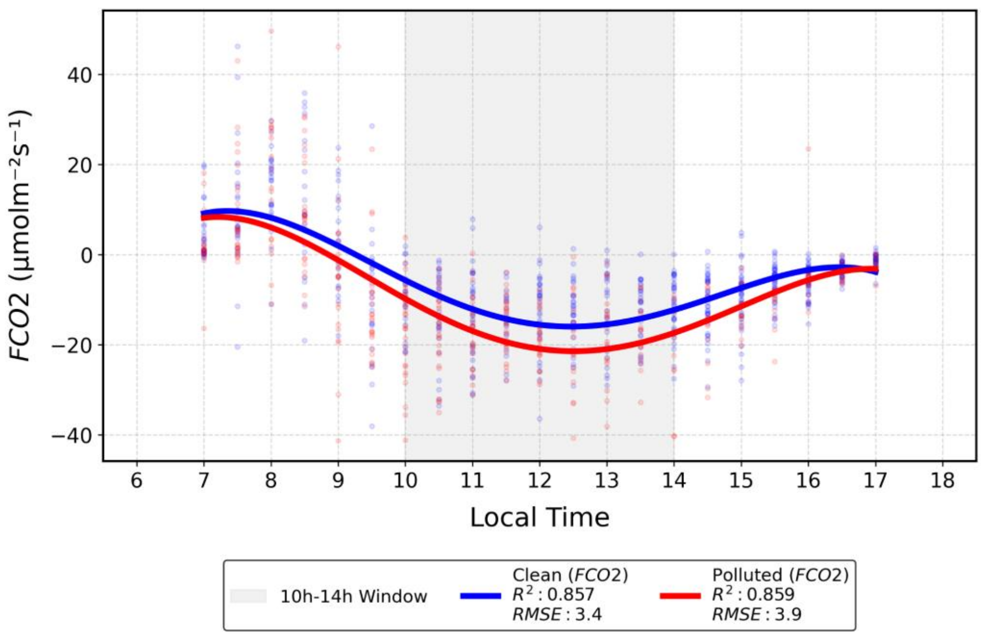

Figure R3. Diurnal cycle of CO_2 flux (FCO_2) during the dry season (2016–2022) under Clean (blue) and Polluted (red) regimes, highlighting the 10:00-14:00 LT period (Figure 7 in the new version of the manuscript).

The study estimates a cooling effect of 0.53C from aerosol on the forest-atmosphere interface. The authors should estimate what this means for forest surface temperature using the LW out fluxes, this is more relevant as the energy fluxes are driven by surface temperature rather than air temperature.

We thank the reviewer for this comment. In this study, forest surface temperature can be evaluated independently of LWout, because infrared surface temperature (Ts) was directly measured throughout the study period. Based on these measurements, mean Ts values were 32.6 ± 3.8 °C for the Clean regime and 31.7 ± 3.9 °C for the Polluted regime, indicating a surface cooling of 0.9 °C associated with aerosol conditions. For comparison, the corresponding air temperature difference between the two regimes was 0.3 °C.

The following sentence has been added to the revised manuscript.

L249-250: "*The cooling between the 10:00 and 14:00 LT regimes implies an average reduction in canopy surface temperature of 0.9 °C (not shown here), based on infrared surface temperature measurements, and a corresponding reduction in air temperature of 0.3 °C, resulting in a −2 hPa (13%) decrease in VPD.*"

In addition, Table 1 (in the revised manuscript) has been updated to include detailed information on the infrared surface temperature measurements.

Some parts of the work appear rather descriptive. Here two examples

i) 247..the authors need to elaborate more specifically why/how this would lead to an increase in evapotranspiration

We thank the reviewer for this comment. We have revised the text to clarify the physiological mechanism linking enhanced CO_2 uptake and evapotranspiration. In addition, we estimated water-use efficiency (WUE) using FCO_2/LE as a proxy to address the link between photosynthetic gas exchange and evapotranspiration, and revised the discussion accordingly.

L269-300: "*In the Polluted regime, CO_2 fluxes were more negative (Figure 7), indicating increased CO_2 uptake by vegetation related to photosynthetic activity. Such enhanced photosynthesis may be linked to changes in stomatal regulation that allow greater CO_2 uptake without a proportional increase in transpiration, reflecting higher stomatal conductance efficiency (Liu et al., 2022; Crous et al., 2025). However, analysis of the LE, which represents the fraction of available energy converted into evapotranspiration, shows a consistent decrease in the polluted regime compared to the Clean regime (Figure 6).*"

L302-307: "*The apparent paradox of an increase in CO_2 absorption alongside a reduction in LE can be explained by differences in water use efficiency (WUE). According to Dekker et al. (2016) and Yang et al. (2016), WUE is defined as the ratio of carbon assimilated to water transpired by vegetation. In this study, WUE was estimated using FCO_2/LE as a proxy. WUE was significantly higher under Polluted compared to Clean regime(mean values of 0.042 and 0.029, respectively, $p < 0.05$). This indicates that under Polluted regime, vegetation assimilates more carbon per unit of water lost, consistent with the observed reduction in latent heat flux (Figure 6) despite enhanced CO_2 uptake (Figure 7).*

ii) Regarding impacts of aerosols on evapotranspiration and the relation to the CO2 enhancement, there is a key discussion missing around what happens to stomatal conductance.

We agree with the reviewer and have revised the manuscript to address the role of stomatal conductance in the discussion, as detailed in the response to the previous comment (L106-123, in this document).

Line 35 The references in this line should come in parenthesis. Same in line 44

Thank you for pointing this out. The reference formatting in lines 35 and 45 has been corrected in the revised manuscript.

236 -237 this sentence is unclear: 'The sum of H and LE was also found to be 67.85Wm−2 lower for the clean regime than for Rn,'

Thank you for pointing this out. We agree that the sentence was unclear. To address this issue, we revised the text to avoid redundancy. A discussion of the surface energy balance closure has been included (L278), and the sentence referring to the sum of H and LE relative to Rn has been removed (L286) as follows:

L278-281: "*The surface energy balance closure was 0.89 for the clean regime and 0.88 for the polluted regime, comparable to values reported in the literature (Mauder et al., 2024). The corresponding residuals were of similar magnitude (70 Wm^{-2} for clean and 75 Wm^{-2} for polluted), indicating that the observed differences in energy fluxes are not related to differences in energy balance closure*."

L283-285: "*Sensible heat decreased by an average of -21.7 Wm^{-2} (13.5 %), reflecting reduced energy transfer to the atmospheric boundary layer. Similarly, LE decreased by -8.9 Wm^{-2} (2 %), indicating limited evapotranspiration due to the reduced radiative energy available. The Bowen ratio, which relates H and LE, recorded 0.38 in the clean regime and 0.33 in the polluted regime, suggesting that a higher proportion of energy was allocated to latent processes, as expected in forest environments.*"

238-239: this could also be clearer : *It appears that the polluted regime is further from the energy balance close, suggesting a change in how this energy is distributed.'*

Thank you for this comment. The sentence has been removed, as the revised manuscript now includes a discussion of energy balance closure as detailed in response to the previous comment.

Line 250 add units to VPD

The text has been revised accordingly. Thanks.

Line 255 water 'emitted' by evapotranspiration?

We thank the reviewer for pointing this out. We agree that the original wording was imprecise. The text has been removed.

References

Crous, K. Y., Middleby, K. B., Cheesman, A. W., Bouet, A. Y., Schiffer, M., Liddell, M. J., Barton, C. V., and Cernusak, L. A.: Leaf warming in the canopy of mature tropical trees reduced photosynthesis due to downregulation of photosynthetic capacity and reduced stomatal conductance, New Phytologist, 245, 1421–1436, https://doi.org/10.1111/nph.20320, 2025.

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