

Review of “How Rainfall Events Modify Trace Gas Concentrations in Central Amazonia”

Overview:

This manuscript analyzes vertical mixing ratio profiles of trace gases measured in the Amazon Forest at the ATTO field site. To examine the effects that rainfall has on vertical profiles of trace gases, the measurements are grouped into times relative to the peak rainfall rate. The analysis then looks at the differences in concentrations at various heights before and after the peak rain fall, with the intent of highlighting processes such as vertical mixing, chemical reactions, emissions, and uptake (i.e. sources and sinks).

This is a valuable data set and analysis, and the results are interesting, but there are some concerns with the approach and the interpretation of the results which are outlined below.

General Comments:

- 1) Figure clarity must be improved. The font size in all the figures is too small to read. It is difficult to distinguish individual lines in Figure 3. The colour scales should all be symmetrical around zero (so that zero is the same colour in each plot). And the panels in the supplementary figure appear to be out of order and unlabelled.
- 2) Concentration is used through to describe mixing ratios, except for one instance (343) where the measurements are referred to as “mole fraction”.
- 3) Statistically, showing confidence intervals (CI) with a median value gives no way of interpreting statistical significance. The CI is the confidence in the calculated mean, not the median. If you want to show the variation in data, show the median and percentiles. If you want to show statistical significance to compare different means (which I think is the case here), you need to show mean and CI. If there is a problem with outliers influencing the mean value (which is perhaps why you are using medians), consider using a truncated mean instead.
- 4) The methodology of the composite analysis is poorly explained. Consider demonstrating this with some variables. If you define $t_0 = 0$ as the time of peak rainfall, then the median profile at t_0 ($\pm 1/2$ hour) is $C_0(z, t_0)$, and the differences (not fluctuations) are calculated for each height and time as $\Delta C(z, t) = C(z, t) - C_0(z, t_0)$, where $C(z, t)$ is the median vertical mixing ratio profile using all values at time t ($\pm 1/2$ hour). If this is a correct interpretation of what was done, then $\Delta C(z, t_0)$ will be zero for all z values. But this isn't the case in the figures (e.g. Fig. 4a, 5c,d,f, and 6a-d). More explanation of the process and why $\Delta C(z, t_0)$ isn't zero is needed.
- 5) While the requirement to reference all the data to a single common time (peak rainfall rate) is understandably necessary, it isn't clearly argued that this is the best choice. For example, if modellers want to use these results to improve predicted concentration measurements during and after rainfall events, how would this reference be useful for them? Why not use a certain minimum

threshold value so that the reference time is the start of the rainfall event? The authors should at least provide some demonstration of analysis to show why peak rainfall rate is the better reference point.

- 6) No statistical analysis of the rain events is given. The reader has no knowledge of how long the rains typically are or when they occur. How does the 4-hour window shown in the figures compare to length of time of a typical rainfall? Presumably, rainfall rate with time would be one of the most important variables for this analysis, but it is missing in discussion and presentation of meteorological variables.
- 7) There is a flaw in the interpretation of the results (at multiple points in the discussion) where higher values of ΔC when $t < 0$ are referred to as “increases” in concentration. This seems to imply a causal relationship where rainfall near $t = 0$ results in an increase in concentration at $t < 0$. While there might be some changes in the forest in “anticipation” of a rain event, this still seems like a misinterpretation. In reality, the concentrations are decreasing from an initial pre-rain profile at $t < 2$ hours. This again demonstrates why it would be better to set the reference point as the start of the rain event (or at the very least to use results to demonstrate why that isn’t the better approach).
- 8) In all the cases shown, the rain results in some observable value of ΔC over a 4-hour period (although the statistical significance of the change is never demonstrated), which seems like it would continue past $t > 2$ hours. How long a period would you need to analyze to demonstrate that the profile returns to its original shape (i.e. $\Delta C = 0$ for all z)? If the rainfall events are evenly distributed in time, then it should be possible to show this. But if rainfall events are only occurring during certain parts of the day (during an increase in temperature for example), then your analysis isn’t separating out both effects. If ΔC continues to change for many hours passed the rain event, then can you attribute the changes to the rain event at all? Showing that $\Delta C = 0$ over some given time would give more confidence in the analysis.

Specific Comments:

- 1) The discussion of previous works looking at the effect of rain in the forest could be strengthened. The Gerkin et al. measurements of ozone are mentioned, but very little information is given. Additionally, Wang et al. and Sigler et al. are referenced later in the discussion, but there is no mention of these related works in the Intro.
- 2) Many subjective or overly descriptive terms are used in the manuscript. These include “well-equipped” (27), “invaluable” (31), “extensively” (43), “precisely captured” (100), “state of the air instruments” (105), “consistently delivers data with remarkable precision” (106), “exceptional stability” (108), and “rigorous testing” (109).
- 3) There are also many instances where the language is too strong for the results shown. For example, I would request changing “point at” 279 to “suggest”; “directly linked” (282) to “correlated”,

“probably due” (329) to “possibly due”; “indicates” (355) to “suggests”; “can” (379) to “could”; and “indicate” (412) to “suggest”.

- 4) I could be wrong, but I don't think canopy height was given in the manuscript (although it can be roughly inferred from the figures). Please add an indication of canopy height to Figure 1 either as a dashed line or as an axis scale (on the right) of z/h_c .
- 5) At (114) how many is “several”?
- 6) For the met variables (121-136), give all the measurement heights.
- 7) At (144) what is meant by “This study”?
- 8) At (194) what is meant by “leading”?
- 9) At (224) what is meant by “particular”?
- 10) In the discussion of R_n activity (236 to 240), the confidence intervals (CI) shown in Fig. 2 suggest that the changes in time described in the text aren't statistically significant. To demonstrate that the changes are significant you would need to show $dC/dt >$ the CI of dC/dt .
- 11) Lines (263 to 278) should go in the Introduction.
- 12) Add a reference for the sentence at (283-284).
- 13) At (288), do you mean “less important at night”?
- 14) At (296), it's not clear how you know “Under daylight conditions and before the rain event, CO profiles exhibit a strong source near the ground and show lower concentrations near the canopy”. Fig. 4 shows ΔC not C . This is also the case for (307) “During the day, the overall picture changes completely with rainfall, shifting from a strong vertical gradient towards a relatively well-mixed layer from the ground to 79 m.” and (311) “inversion of the profile”. Because Fig. 4 just shows change, there is no way to know that the profile has inverted.
- 15) Lines (297 to 306) discuss CO emissions in general, but I don't see the connection to rain events.
- 16) At line (317) “throughout both day and night periods”, refer back to Figure 1.
- 17) At line (337), where is standard deviation shown and what data set is it from?
- 18) At (372), how would NO₂ be “washed out”?
- 19) At (384), I would suggest changing “As soon as rain starts...” to “Typically, when rain starts in a forest...” (to emphasize you are not discussing your data).

20) The discussion at Lines (390 to 396) is very speculative and should be rewritten without the speculation and subjective language (or removed completely).

Technical Corrections:

(Line 4): NO₂ written twice.

(6): Remove "its"

(38): "measurements" should be "concentrations".

(47): "originating" would be better than "coming from".

(49) delete "of".

(67) Missing space before reference.

(75) What does "depend on and independent" mean?

(78) Put citation in brackets.

(87) "vertical profile measurements" might be better than "measurement profiles"

(88) "vertical profile"

(99) delete "respectively"

(105) delete "specifically with"

(109) Is the serial number relevant?

(113 + other locations) "instant" should be capitalised.

(169) "tipping amount" or "tipping threshold"

(224) replace "its" with "the nighttime"

Figure 3: New sentence at "Air temperature was measured at a height of..."

(349) "Figure 5..."

(352) "from" instead of "in"

(362) replace "as to be" with "is"

(411) Space before NO₂.

(423) "variability patterns"