Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-65-RC1, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Wildfire smoke in the lower stratosphere identified by in situ CO observations" *by* Joram J. D. Hooghiem et al.

Anonymous Referee #2

Received and published: 13 April 2020

GENERAL COMMENTS

The paper "Wildfire smoke in the lower stratosphere identified by in situ CO observations" presents measurements of CO mole fractions, CO2 mole fractions, and isotopic composition of CO from two balloon-borne instruments. Overall, the paper presents new datasets and includes in depth analysis of the measurements. It is generally well-written, with clear discussion of results. The paper would make a good contribution to ACP, after the following comments are addressed.

For the most-part, I found the description and justification for the methods chosen were complete and well-referenced. However, I do not have the expertise to fully evaluate some details of the data collection and analysis methods (Sect. 2.1, 2.2 2.3.2, 2.3.3). In some sections, I found it a bit difficult to follow the methods. For example, some

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descriptions of the methodology are written into figure and table captions. Throughout the paper, it would be helpful if high level information was provided at the beginning of each section to help guide the reader and explain how and why certain methods were applied. I have included some specific comments below, which include examples where additional descriptions would help.

SPECIFIC COMMENTS:

Line 15: “The in situ observations provide information. . . of the 2017 smoke plume” The closing sentence of the abstract is a bit unclear. Is the “information on the trace gas chemistry” what was described in the previous part of the abstract? If so, perhaps could use more specific language (e.g., what new information is provided by this study?). Also, I don’t see much mention of the 1 km width of the plume in the text (I assume this inferred from Sect. 3.1?). If this is a key result, then maybe it warrants more discussion in text.

Line 59 “Methods”: A very short overview of what the AirCore vs LISA measure (mole fractions vs isotopic composition) and to what approximate vertical / temporal resolution would be helpful here.

Line 139: I found it very difficult to understand the method used for the back trajectories until I reached Fig 2 and the associated text in Sect. 3.2, which walks the reader through this process. Until reaching this figure, I found terms like “piece-wise manner” confusing. To remedy this, the authors could merge Sect. 2.3.1 directly into Sect. 3.2 or perhaps make Sect. 2.3.1 a bit more general with a forward reference to Sect. 3.2 (e.g., something like used back trajectories from CLaMS and a piecewise method illustrated in Sect. 3.2).

Line 148: A bit of an overview would be helpful for Sect. 2.3.2 and 2.3.3. How are the methods being applied to the data? What information do the methods in Sect. 2.3.2 provide compared to Sect. 2.3.3? Have these methods been applied to similar datasets before?

Line 152: Did not define “f” in the text. Check throughout that all variables in equations are defined.

Line 191: I found this section confusing at first. I had to jump around the text to understand how Table 3 was constructed and how this information was used. Some of the methods/categories are only really described in the Table 3 and Figure 6 captions. Also, the Table 3 caption references “Monte-Carlo simulation” at the very top of the caption, but the MC simulation is not mentioned until much further in the text. One possible way to improve this would be to give a high level overview when the table is first introduced. This would describe why the table was put together, how the various lines of the table were compiled (with cross-references to relevant sections), the purpose / input parameters of the MC simulation when the table is first introduced.

Table 3 caption: The caption is a bit confusing –review/rewrite and maybe move some of the details into the text describing the methods. For example, “. . . does not significantly affect the results” – the results of what? The MC simulation?

Table 3: Where did the numbers for AP OH-Corrected come from? Are these related to the numbers given around line 337 – if so, how exactly were they chosen (they don’t seem to exactly match any of the numbers given in the text)?

Line 237: “This thus differs. . . in Table 2”. Could you clarify this statement? It looks like the values in Table 3 fall within the range of Table 2 – but are a narrower part of the range (because from specific type of biomass burning?)

Line 240: Please add a bit of a description of the Monte-Carlo simulation. It’s not clear what data is being used, what equation it’s applied to, and what the desired output is until the reader gets to the caption of Fig 6.

Line 255: “The observed CO2. . . Which allowed for determination of enhancement ratio” Is the observed CO2 difference significant for both LISA and AC? It looks like LISA is biased high compared with AC (e.g., non-enhanced day for LISA is comparable

to biggest enhancement for AC). Also, why does the slight increase in CO2 allow for enhancement ratio calculations?

Line 259: This section could use an opening sentence describing what the back trajectories are being used for.

Line 260: What is the "match distance"? Is this the minimum distance from the back trajectory to the CALIOP scan? Also, since the centre/upper altitude are not shown – is this the lower altitude? Is this starting from 13.3 km (based on Sect. 2.3)?

Figure 2 caption: "...the correspondence was sufficiently good". Does this mean the altitude correspondence between the back trajectory and CALIOP aerosol enhancement?

Line 277: How are the slope / uncertainty calculated?

Line 307: How do you know that the plume is clearly not stratospheric? Or is it just clear that the plume is different from background?

Line 332: How did you choose the ranges of possible values from Fig 5?

Figure 5: The numbers in the legend aren't showing up correctly. (No value for the blue marker, reading at 1^6 instead of 10^6 for the orange and green markers)

Line 343: Why is it within the range for "biomass burning" in Table 2 but not within the range for "wildfire smoke" in Table 3?

Line 414: You mention that "little is known of the CO isotopic composition". Do your measurements of the background air mass contribute to this knowledge? If so may be worth mentioning the background measurements in the abstract.

Line 426: "Yet another event was modelled..." is this another wildfire event? If so, specify.

TECHNICAL CORRECTIONS:

Line 10: “Back-trajectory analysis, performed with. . .. Date of 12 August 2017” Very long sentence. Consider breaking it up.

Line 13: “Colombia” –> “Columbia” (also, line 426, 434)

Line 145: “Wherever the distance was below”, replace with “Wherever the distance was smaller than”

Line 245: “its” –> “it is”

Figure 2 caption: Check capitalization after periods. Also, last sentence is run on “CALIOP, the time” –> “CALIOP. The time”

Line 307: “, see Table 4” –> “in Table 4”

Line 308: “stratospheric” –> “the stratosphere”

Line 309: “it cannot be excluded” –> “it cannot be ruled out”

Line 356: delete repetion? “. . . was used to determine fractions of tropospheric and stratospheric air in the plume”

Line 414: “pollution air” –> “polluted air”

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