

Summary/recommendations

This study combines FIREX-AQ biomass burning (BB) observations of dusk and nighttime plumes with a chemistry box model to elicit numerous details related to NO_3 , O_3 , and OH oxidation, BBVOC oxidation, and product formation in the plumes. Nighttime and/or optically thick plume chemistry remains understudied in the active BB world. This study did an excellent job detailing anticipated chemistry, with an emphasis on NO_3 and NO_x reactions. It was well-written and easy to read. I especially commend the authors on their admirable constraint with regards to sentence length. The figures are generally quite extensive but are mostly presented in an attractive, consistent, clear, and readable manner. While readable and clear, the paper is quite long and the authors may want to consider whether any details could be moved to the supplement. I recommend publication after addressing my mostly minor comments below.

General comments

Line 139: I would like a little more discussion on how close to or far away from Lagrangian sampling each flight was. If this has been well characterized, perhaps an SI table is appropriate. ‘Semi-Lagrangian’, while often used in the BB literature, is vague.

Sect 2.1: It’s no secret that UHSAS have struggled with saturation in high-aerosol environments such as wildfire plumes. While not one of the most crucial measurements in this paper, I recommend including a brief discussion in the text or SI about its performance for the specific plumes used in this work.

Related, the UHSAS (Twin Otter) and SMPS (DC-8) are on 1 Hz vs 60 s timescales. How did you account for this difference in your analysis? (Especially since you assumed center-line modeling and the SMPS almost certainly did not capture only the center of a plume in 60 s).

Section 2.1.1-2.1.2: (Twin Otter and NASA DC-8 descriptions) Were there any opportunities during FIREX to characterize instruments (specifically, instruments measuring the same species) from each aircraft against each other? If yes or no, could you briefly detail. Is it anticipated that ‘real’ individual differences in a given species present at each fire studied greatly outweigh differences (uncertainty) between two different instruments and platforms measuring said species?

Line 202: Why only one “Dark” case? Please provide a brief justification, including why you chose the WF2 case as the dark case’s template.

Lines 236-7: what qualifies as “small” uptake coefficients and aerosol diameters here? Are the aerosol diameters appropriate for this equation (3) appropriate for the (non-coarse) mode/s observed?

Some of the discussion between Sect 2.3.1 Chemistry and Emissions and Sects 2.3.2-3 seem a little disconnected. Are you using the ER inventory (Sect 2.3.1) only for compounds not measured directly that are still important to MCM mechanisms? Also it seems that Eq 1 does not care about background (out-of-plume) concentrations of species. Is that the case, and if so can you briefly justify using total rather than background-corrected concentrations (mixing ratios)?

Relatedly, it's slightly unclear to me exactly what the box model used consists of. It uses the MCM and a NOAA F0AM BB mechanism. Are those the only components to it (along with the dilution rate discussed)? Has this exact model been used elsewhere?

Line 320: make sure to note that you are using 'delta' notation to denote background-corrected (I don't think this notation was previously defined).

Line 326-329: briefly justify why you're using the latter transects of the WF2 fire rather than the former.

Line 381 & elsewhere: Why is formaldehyde separated from other BBVOCs in the analysis?

Lines 409-411: Why do BB plume have more pronounced reactivity for NO₃ than for OH or O₃? If discussed elsewhere, point to that discussion.

Line 496: Akherati et al., 2020 also an appropriate citation here:

Oxygenated Aromatic Compounds are Important Precursors of Secondary Organic Aerosol in Biomass-Burning Emissions: Ali Akherati, Yicong He, Matthew M. Coggon, Abigail R. Koss, Anna L. Hodshire, Kanako Sekimoto, Carsten Warneke, Joost de Gouw, Lindsay Yee, John H. Seinfeld, Timothy B. Onasch, Scott C. Herndon, Walter B. Knighton, Christopher D. Cappa, Michael J. Kleman, Christopher Y. Lim, Jesse H. Kroll, Jeffrey R. Pierce, and Shantanu H. Jathar, *Environmental Science & Technology* 2020 54 (14), 8568-8579, DOI: 10.1021/acs.est.0c01345

Line 588-593 (paragraph) be careful with wording here. For example- "Further, the nitrocatechol yield changes to 27 % – 50 % (Figure 9 D) when varying total BBVOC emissions by a factor 0.5 – 4." Change the order of one of these number pairs--from Fig 9D the yield is 50% at a BBVOC factor of 0.5 and drops to 27% by a BBVOC factor of 4.

Lines 606-609 (paragraph): If the reactions & temperature dependence are uncertain, how did you obtain an estimate of phenolics/NO₂ for 268 K?

Line 640-41: citation for these estimated PNA and PAN lifetimes?

Line 643 & associated figure caption: define $\text{CH}_3\text{O}_2\text{NO}_2$ (methyl peroxy nitrate?).

Figures/Tables

Figure 2: while useful for Sect 2 discussion, I suggest considering whether this figure could be moved to the SI. It is quite large and there are already an extensive number of detailed figures.

Figure 3 caption: I suggest reminding the reader what ‘all model runs’ means in “Average (all model runs)..” .

Figure 4: I suggest increasing whitespace between the OH and NO_3 bar clusters just a bit to make the distinction between the two more clear.

Figure 5: same comment, please space the ‘subpanels’ out a little more (that is, add more whitespace in between each subplot).

Figure 7: note for final publication that the right-hand line on panel D got cut off. I suggest adding a legend for the different colors (O_3 , NO_3 , OH) within the figure to make it more easily interpretable to the reader (rather than having to repeatedly refer to the figure caption). Could copy over legend from Fig 6.

Figure 8: it’s a little difficult to read ‘Castle’-- could consider enlarging all fire names on this.

Figure 9: Panels C and D appear to be out of order (not going from left to right) . Also ‘BBVOC’ is used throughout in the text-either update figure captions from VOC or note in caption that you are using ‘VOC’ for “BBVOC” here, if that’s correct. Or note why you use VOC instead of BBVOC here if it’s for another reason.

Supporting information

I’m fine with having multiple short tables on the same page, but I suggest increasing the whitespace between each paper. Since the title and caption are in the same font, page 11 of the SI is hard for me to quickly parse. Also, isn’t it ACP convention to put table captions at the top of the table? (Or is that just what most people have done previously.)

Page S2, Mechanism section (line 1202)-I’m a little confused by the comment “reactions in red are already in the MCM and will need to be replaced when used in conjunction with an MCM mechanism.” Maybe the meaning here is clear to regular MCM users, but by “replace” do you mean “remove”? Could you expand on this note a little more to make the meaning more clear?

Technical comments

Line 186: looks like the WF1 and WF2 fires should be referred to as Fig 1B and 1C. Note that in discussing the Cow fire (lines 195-199) you don't refer to Fig 1E.

Line 376: switches between X and x, are these meant to be consistent (X or x)?

Line 424: missing parentheses around Decker citation.