Anonymous Review of *Transport of Biomass Burning Aerosol into the Extratropical Tropopause Region over Europe via Warm Conveyor Belt Uplift*

Anonymous Reviewer

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1 Summary

In this work, Joppe *et al.* studied the transport of biomass burning aerosol into the extratropical upper troposphere and lower stratosphere (exUTLS) through a warm conveyor belt. This was a case study of one event that occurred during Flight 7 in the TropoPause compositon gradients and mixing Experiment (TPex) campaign.

During the TPex campaign, a Learjet 35A flew a package of in-situ and offline measurements. The in-situ aerosol measurements were sizing from a UHSAS, OPC, and mcCPC, as well as non-refractory aerosol chemical composition from a miniAMS. The in-situ gas phase measurements were N_2O, CO, and O_3. There were also offline aerosol measurements. These include a filter-based collection that was rinsed and run through an HPLC and then through an orbitrap. There was also a cascade impactor that held TEM grids for offline SEM-EDX analysis. Finally, a similar suite of in-situ measurements was taken on the Towed Sensored Shuttle (TOSS) to measure vertical gradients.

Overall, this is a very well-written paper with very few technical comments. However, I have two major comments that, if addressed, I think will increase the clarity of the paper and strengthen its message.

2 Major Comments

1. My first major comment is on the rBC calculation. Refractory BC is generally a small component (<5%) of fresh biomass burning smoke. For example, the study by Yu et al. shows that freshly injected pyroCb smoke in the stratosphere from the Pacific Northwest Event was ∼2% rBC, which accounted for its incredible rise to 23 km. The estimate that rBC may be

almost 40% and 20% of the tropospheric and UTLS aerosol mass, respectively, is difficult to reconcile with many of the previous in situ measurements at these altitudes (see ATom and HIPPO campaigns). The authors are careful to point out their rBC calculation is an upper estimate, but I think these estimates are so far off that this warrants further explanation.

2. The above major point affects the heating rate calculated in Section 3.3, and will also affect the radiation simulations cited at the end of Section 3.3.

3. The other major comment is that the SOAP analysis, in which the filters were washed and analyzed with HPLC and orbitrap mass spectrometry, seems relatively weak to me. The CO + UHSAS, AMS, TEM grid and back trajectory analysis are all much stronger evidence that this pollution event is from biomass burning. Certainly, the technique seems strong, but I feel that removing these results from the main paper would tighten its focus and make it stronger. This reviewer suggests that they can be moved to the supplemental section if needed.

3 Minor/Technical Comments

- P11L244: In Figure 4, it is unclear to me whether the data in all the plots is from the TOSS or from the Learjet cabin.
- P12L272: How many of the grid particles were non-refractory vs refractory?
- P12L274: Are soot particles considered refractory or non-refractory in this analysis? More details regarding the TEM grid analysis needs to be outlined either here or in the experimental section.
- P13L284: There needs to be a space between g and cm^{-3}.
- P14L291: If you look at Figure 11 of Brock 2021, you can see that there is some contribution from sea salt and dust to the submicron aerosol mass. Furthermore, there are likely to be non-refractory salts like KCl in biomass burning aerosol.