

Response to RC1:

Reviewer comments in black and response in red.

This manuscript describes analysis of wildfire smoke events over the Baltimore-Washington region using multiple observations and trajectory model simulations. It brings together these multiple lines of evidence for four different events and shows how there can be different transport regimes even for similar satellite signals. The paper is generally well-written and presents interesting results; I think it will be acceptable for publication with relatively minor revisions.

» The authors thank the reviewer for encouraging feedback on our work and for recognizing the need of using multiple observational and modeling tools to evaluate Canadian wildfire smoke events. We appreciate the helpful feedback and will address the individual comments in detail below.

Major Comment: The manuscript focuses on 4 episodes, but contains no discussion of how these were chosen or how these 4 episodes fit into the variations for 2023 (or any other year). Line 91 states “analysing four representative case studies for different plume-PBL interaction scenarios”, but I see no discussion of why representative. The Results section starts straight away with the first case study. There needs to be a discussion of how the 4 events were chosen. There also needs to be a discussion of how these episodes compare with the rest of the summer. E.g., Are these the only 4 smoke events (using some criteria)? How does the PM_{2.5} compare with the rest of the summer? The think plots show a few quantities for each day of the summer would help, both introducing the events and also showing if other events.

» We thank the reviewer for raising this important point. The reason we chose 2023 as the study year is that it was an exceptional wildfire season in Canada, one of the largest on record, with nearly 15 million hectares burned (Jain et al., 2024; Natural Resources Canada, 2024). The smoke from these fires had far reaching implications for health and air quality across North America, with several major cities in the United States of America experiencing unprecedented poor air quality days and severe visibility reductions. These conditions provided strong motivation for us to analyze this year in detail.

Within 2023, the four episodes presented in our manuscript were selected because they represent contrasting transport and mixing scenarios that were clearly captured in the Beltsville dataset. Specifically: (i) a smoke plume apparently lowering into the residual layer followed by frontal

flushing (24-25 May), (ii) a plume showing apparent subsidence under stagnant conditions leading to surface accumulation (5-6 June), (iii) a multilayer intrusion interacting with both residual and convective PBLs (15-17 June), and (iv) a horizontally advected plume already well mixed in the PBL with extreme surface impact (28 June-1 July).

We agree that this rationale was not sufficiently explained in the original draft. In the revised manuscript, we have added a short introductory paragraph at the start of Section 3 clarifying why these cases were chosen and placing them in the broader context of the 2023 summer variability. This addition makes clear that the four events are illustrative, not exhaustive, and were chosen because they represent distinct plume-PBL interaction regimes that could be analyzed with confidence.

Minor Comments.

1. I agree with comments in CC1, especially the length of trajectories shown and the PBL height.

» We have already addressed the trajectory length and PBL height in response to CC1. Specifically, all trajectories have been recomputed using GFS data to the full 72 hr. length and we now overlay PBLH (mixing layer height) estimates on the ceilometer backscatter profiles (see revised Figs. 4, 6, 8, and 10).

2. Line 196. I am not sure “End of May 2023, the ...” is correct grammar.

» We agree the original phrasing was incorrect. We have revised “End of May 2023, the ...” to “At the end of May 2023, the ...” for clarity.

We sincerely thank the reviewer for constructive feedback and positive assessment of our manuscript. The comments have helped us clarify the rationale behind case selection, improve the consistency of terminology, and strengthen the figures by including full-length trajectories and explicit PBL or mixing layer height overlays. We believe these revisions improve both the clarity and scientific rigor of the paper, and we are grateful for the reviewer’s thoughtful input.