Response to Reviewer CC1

Reviewer comments in black and response in red.

This is a very interesting data set in Beltsville, MD, USA. It appears to be a valuable, specialized resource for studies like this. It will be great to learn more about it and for the science community to have eventual access to these data. Much of the paper deals with "descent" of smoke layers as manifested in lidar time-series data.

» The authors would like to thank the reviewer for the careful reading of our manuscript, constructive positive feedback, and recognition of the value of the Howard University Beltsville Campus (HUBC) dataset. We are happy to provide the data, additional figures, and processed products upon request. We are actively trying to build a public data repository that will make the HUBC dataset broadly accessible to the scientific community. Our webpage contains more information and updates on our data activities: https://hu-bc.org/hubc/

In section 2.2 (Measurements and Instrumentation), we have added a line at the beginning to highlight the novelty of the HUBC measurement site. **Line # 154-156**

I would caution that sloping aerosol and cloud features in such data representations may not be attributable to meteorological forces or sedimentation. A lidar time series simply shows what is blowing overhead at different times. There's no way to know a particle's vertical history or future from such a rolling snapshot of a particulate layer. Please see a comment posted to an ACP paper published back in 2010: https://acp.copernicus.org/articles/10/11921/2010/acp-10-11921-2010-discussion.html

» Thank you for sharing the ACP discussion, it was very helpful. On the "descent" of smoke plume, we fully agree with reviewer's caution. A downward sloping feature in a Eulerian time-height curtain is not proof of subsidence or gravitational settling. As reviewer pointed out in the ACP discussion of a similar case, sloping structure can result from shear/tilt and evolving horizontal gradients blowing through the beam, without additional context a vertical aerosol backscatter curtain alone cannot prove vertical motion. To address this, we have softened our terminology from "descent" to "apparent lowering over the site", unless multiple lines of evidence support subsidence, and we have added that nuance explicitly in section 3 of the revised text.

For some reason, all the HYSPLIT trajectories are shorter than the specified 72 hours. Note the time series below each one. I suspect that this is an artifact of the HRRR data choice. The HRRR data are not global. It can be seen that some of the trajectories end up at about the same latitude in Canada. Maybe that's the edge of the HRRR data grid? I tested one of the scenarios, using GFS global data, and the results came out as 72 hours long. Regardless of the reason, the 72-hr premise is not borne out in the data.

» Good catch. The reviewer rightly pointed out that the HYSPLIT trajectories are shorter than 72 hr. In methods we wrote that all back trajectories were computed for 72 hr. using HRRR (3-km) meteorology (CONUS + southern Canada coverage), but the figures you rightly flagged end before 72 hr. because of HRRR's limited domain causes back trajectories to terminate once parcels leave the grid. This was our oversight; we should have noted the domain limit and used a global field for the plotted cases. We have now rerun all displayed trajectories with GFS to full 72 hr. and updated the captions to list the meteorological driver and duration. This correction does not change our interpretation; we treat trajectories as transport pathways rather than definitive proof of source.

We retain 72 hr trajectories (now rerun with GFS) to preserve synoptic context to Canadian smoke affected regions, but we emphasize the final 24-48 hr in our interpretation and note the associated trajectory uncertainties (Stein et al., 2015; Stohl, 1998). In the revised manuscript, we have corrected Section 2.2.3 and updated Figures 3,5,7, and 9 and their captions accordingly.

Speaking of trajectories, it might not be the case that they show an "origin" any more than a possible path through smoke. There is no information inherent in the trajectories indicating a polluting origin point. The fact that the trajectories illustrated in the paper are all shorter than stated adds to the uncertainty of their interpretation. But even when that is corrected, the trajectory paths and endpoints by themselves do not identify a smoke-initiation point.

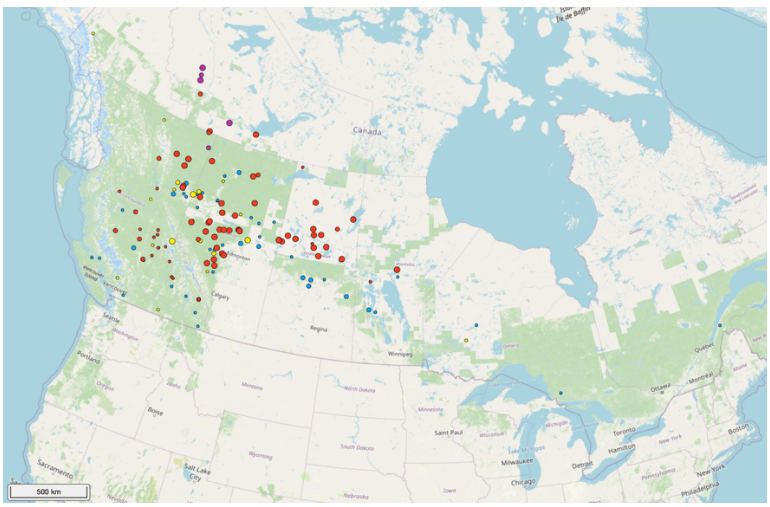
» We agree with the reviewer's point. Trajectories do not by themselves indicate a source origin; rather, they illustrate possible transport pathways conditioned on the meteorological fields. To address this, we have revised wording throughout the manuscript to replace phrases such as "originated from" with "consistent with transport from regions affected by Canadian fires." In addition, our identification of fire source regions was not based on trajectories alone. We used fire location information from the Canadian Interagency Forest Fire Center (via the Canadian Wildland Fire Information System), together with HYSPLIT trajectories, synoptic maps, and satellite imagery, to piece together a consistent picture of source regions and plume transport. This multi-evidence approach avoids over-interpretation of the trajectories as stand-alone "origins".

Section 2.2.6 (2.2.6 Canadian Fire Source Data) is added to the revised manuscript.

2.2.6 Canadian Fire Source Data

We obtained approximate fire source locations from the Canadian Interagency Forest Fire Centre (CIFFC) via the Canadian Wildland Fire Information System (CWFIS) (https://cwfis.cfs.nrcan.gc.ca/). These maps and data products are based on the best available fire reports but may not always reflect the current fire situation in real time. This study employed CIFFC fire locations, HYSPLIT trajectories, synoptic weather maps, and satellite images to find the places that best matched the observed smoke plumes and their transport patterns. This multi-evidence method avoids assigning the term "origin" simply to trajectory analysis.

Lines 259-265



For illustration, we attach here a representative CWFIS map for 21 May 2023 showing the active fire locations that informed our analysis. This figure is not included in the manuscript, since it mainly serves to demonstrate the input dataset rather than the results.

The PBL is central to this manuscript. I could not tell from the illustrations where the variable PBL was. Plotting the PBL throughout the lidar time series curtains would be a wonderful addition.

» We agree with the reviewer that the PBL is central to the manuscript and that its depiction in the ceilometer profiles should be more explicit. At present, our captions occasionally rely on qualitative cues (e.g., “PBL is visible as the region with varying depolarization”) rather than a quantitative marker. To address this, we have now computed the PBL height from the CL61 backscatter profile using the Vaisala's proprietary software BL-view and plot it as an overlaid line in each backscatter profile. In this manuscript, references to "PBL height" specifically denote the mixing layer height retrieved from lidar, which we treat as a proxy for the planetary boundary layer height (e.g., Emeis, 2008; Seibert et al., 2000). This addition makes the diurnal evolution of the PBL explicit and removes ambiguity in interpretation.

We appreciate the reviewer's careful reading and practical suggestions. Their points on "descent," the trajectory duration, and the need to show PBL height more clearly pushed us to make several useful corrections/additions to the manuscript. In the revised version of the manuscript, we have softened the terminology, reran the HYSPLIT back trajectories with a global dataset, and added PBL height overlays to the backscatter profiles. These adjustments have improved both the clarity and accuracy of the analysis.

References:

Emeis, Stefan, Klaus Schafer, and C. H. R. I. S. T. O. P. H. Munkel. "Surface-based remote sensing of the mixing-layer height-a review." *Meteorologische Zeitschrift* 17, no. 5 (2008): 621.

Seibert, Petra, Frank Beyrich, Sven-Erik Gryning, Sylvain Joffre, Alix Rasmussen, and Philippe Tercier. "Review and intercomparison of operational methods for the determination of the mixing height." *Atmospheric environment* 34, no. 7 (2000): 1001-1027.

Stein, A. F., R. R. Draxler, G. D. Rolph, B. J. B. Stunder, M. D. Cohen, and F. Ngan. "NOAA's HYSPLIT Atmospheric Transport and Dispersion Modeling System", *Bulletin of the American Meteorological Society* 96, 12 (2015): 2059-2077, doi: https://doi.org/10.1175/BAMS-D-14-00110.1

Stohl, Andreas. "Computation, accuracy and applications of trajectories—A review and bibliography." Atmospheric Environment 32, no. 6 (1998): 947-966.