

Response to Comments of Editor:

We highly appreciate the editor for valuable comments. The editor's comments are laid out below in black text, and specific concerns have been numbered. Our responses are given in blue text, and changes/additions to the manuscript are given in red text.

- **Black: the edit's comments.**
- **Blue: the authors' responses.**
- **Red: Quotes from the revised manuscript.**

General comments

Thank you for thoughtfully responding to the review in detail. I have now carefully reviewed the paper myself and have a few additional minor revisions (see comments and edits within the attached .pdf document). Please respond to these edits at your earliest convenience. I believe these edits will improve the readability of this nice paper.

Response: We sincerely thank the editor for the careful review of our revised manuscript and for the constructive comments and detailed edits provided in the annotated PDF. We greatly appreciate the time and effort devoted to improving the clarity and readability of the manuscript. Following the suggestions, we have carefully revised the manuscript and provide our point-by-point responses below.

Detailed comments

1. Line 10: in -> sampled from
2. Line 11: ...and quantify
3. Line 14: factor of
4. Line 14:in an urban region
5. Line 15: was observed during winter pollution events
- 6.Line 16: reproducing
7. Line 24: in
8. Line 28: and contribute
9. Line 45: higher

Response to 1-9: We thank the editor for these helpful suggestions. All recommended wording, grammatical, and typographical corrections have been incorporated into the revised manuscript.

10. Line 79: clarify - do you mean heating buildings with fuels?

Response: We thank the editor for this comment. Line 79 has been revised to “While fuel combustion for winter heating promotes the buildup of fine-particle pollution...” to improve clarity.

11. Line 91: ice

Response: We thank the editor for pointing this out. The suggested correction has been made in Line 91.

12. Line 99: Just to check - is this correct? Do you mean that 3 m above sea level? Or do you mean that you sampled 3 m above the surface?

Response: We thank the editor for this comment. To clarify that the 3 m height refers to the aerosol sampling inlet rather than the sampling site, we removed this information from the site description. Instead, the following statement has been added in the measurement system description (Line 107): “Ambient aerosols were sampled through a common inlet located 3 m above ground level (AGL) using the same container-based mobile observation system described in Wang et al. (2025), without an external size-selective inlet.”

13. Line 114: Normally 128 bins & Line 117: Normally 64 bins - please double check

Response: We thank the editor for this comment. We have double-checked the instrument settings. To avoid confusion with the default instrument configuration, we have revised Line 114 by adding “in this study” to clarify that the reported number of bins refers to the actual measurement configuration used in this study.

14. To what relative humidity? Was the RH sampled, if so list here.

Response: We thank the editor for this comment. The sample relative humidity was approximately 10%. To clarify this, we have added the following statement: “..., the particle stream was dried using a silica gel diffusion dryer, resulting in a sample relative humidity of approximately 10%.”

15. native

Response: We thank the editor for pointing this out. The word “native” has been removed from the revised manuscript.

16. Line 134: The National Atmospheric Super Monitoring Station, ... -> the National Atmospheric Super Monitoring Station, ...

Response: We thank the editor for this comment. The capitalization has been corrected, and “The” has been changed to “the” in Line 134.

17. Line 155: to clarify: Clean is less than 35 ug/m3, Moderate is 35.1-75 ug/m3, and high is greater than 75.1 ug/m3. I would suggest listing.

Response: We thank the editor for this suggestion. To improve clarity, the classification criteria have been explicitly listed in Line 155 as follows: “Dust events were identified by $PM_{10} \geq 150 \mu\text{g m}^{-3}$, while non-dust conditions were further separated into Clean ($PM_{2.5} \leq 35 \mu\text{g m}^{-3}$), $PM_{2.5}$ Moderate ($35 < PM_{2.5} \leq 75 \mu\text{g m}^{-3}$), and $PM_{2.5}$ High ($PM_{2.5} > 75 \mu\text{g m}^{-3}$) categories.”

18. Line 167: This is commercially available via Handix Inc.? Company should be listed.

Response: We thank the editor for this comment. The company information has been added in Line 167, and the text now reads: “INP measurements in this study were performed using a commercially available CSU (Colorado State University) Continuous Flow Diffusion Chamber–Ice Activation Spectrometer (CFDC-IAS, Handix Scientific Inc.)”

19. Line 207: Why? I am surprised that higher resolution meteorological data is not available for this region.

Response: We thank the editor for this comment. Higher-resolution meteorological datasets are available; however, we used the GDAS $1^\circ \times 1^\circ$ dataset because it is the standard meteorological input for HYSPLIT and has been widely applied in air-mass trajectory studies across northwestern China and East Asia (Chen et al., 2024). Previous evaluations have shown that trajectories derived from GDAS 1° dataset and the higher-resolution GDAS 0.5° dataset are generally comparable, with differences primarily associated with the treatment of vertical motion rather than horizontal resolution (Su et al., 2015). Therefore, the GDAS1 dataset is considered adequate for the trajectory analysis conducted in this study.

20. Line 244: number of

Response: We thank the editor for this suggestion. The suggested revision has been made in Line 244.

21. Line 249: Would you provide date (or dates) of this festival?

Response: We thank the editor for this suggestion. The specific festival date (12 February 2025) has been added in Line 249 for clarity.

22. Line 255: CSU-CFDC

23: Line 265: of $PM_{2.5}/PM_{10}$

Response: We thank the editor for this suggestion. The suggested revision has been made in Line 265.

24. Line 313: Why do you call $PM_{2.5}$ High, but not $PM_{2.5}$ Moderate. It would be better to always call them either Moderate/High or $PM_{2.5}$ Moderate/ $PM_{2.5}$ High

Response: We thank the editor for this suggestion. To ensure consistency throughout the manuscript, all occurrences have been revised to use “PM_{2.5} Moderate” and “PM_{2.5} High”. The corresponding figure labels and captions, including those for Figs. 3–10, have also been updated accordingly.

25. Line 329: More recent papers available. Here is an example:
<https://www.nature.com/articles/s43247-025-02836-7>

Response: We thank the editor for this suggestion. The recommended recent reference (Ardon-Dryer, 2025) has been added to the revised manuscript and cited in the relevant section.

26. Line 350: I think there is an error in Figure 3 as the R listed seems quite high 0.8? given the plot, is this repeated from above? Why 2 R listed? This is not described in the text, as it states simply insignificant.

Response: Thank you for the comment. We realize that the two correlation coefficients shown in Fig. 6c were not sufficiently explained in either the figure caption or the main text. These coefficients do not represent the relationship between FMD and BC. Instead, they correspond to two separate partial correlation analyses involving INP concentrations: $R(\text{FMD} \mid \text{BC})$, which quantifies the relationship between FMD and INP after controlling for BC, and $R(\text{BC} \mid \text{FMD})$, which quantifies the relationship between BC and INP after controlling for FMD. To avoid ambiguity, we have revised the figure caption and clarified the meaning of both coefficients in the revised manuscript. See Line 351-352: “The reported $R(\text{FMD} \mid \text{BC})$ and $R(\text{BC} \mid \text{FMD})$ values denote the partial correlations between FMD and INP after controlling for BC, and between BC and INP after controlling for FMD, respectively. All correlations were calculated in natural log space.”

Reference

Ardon-Dryer, K.: Minute-scale convective dust events are overlooked in urban air quality monitoring, *Commun. Earth Environ.*, 6, 815, doi:10.1038/s43247-025-02836-7, 2025.

Chen, J., Xu, J., Wu, Z., Meng, X., Yu, Y., Ginoux, P., DeMott, P. J., Xu, R., Zhai, L., Yan, Y., Zhao, C., Li, S.-M., Zhu, T., and Hu, M.: Decreased dust particles amplify the cloud cooling effect by regulating cloud ice formation over the Tibetan Plateau, *Sci. Adv.*, 10, eado0885, doi:10.1126/sciadv.ado0885, 2024.

Su, L., Yuan, Z., Fung, J. C. H., and Lau, A. K. H.: A comparison of HYSPLIT backward trajectories generated from two GDAS datasets, *Sci. Total Environ.*, 506–507, 527–537, doi:10.1016/j.scitotenv.2014.11.072, 2015.