

Comments on the manuscript (No. egusphere-2026-308) entitled “*Dust transport and local anthropogenic emissions differently shape atmospheric ice-nucleating particles: Insights from an industrial urban atmosphere*” by Jiawei Yang, et al.

***General comments:***

Atmospheric ice-nucleating particles (INPs) play a critical role in cloud formation, cloud radiative properties and precipitation through heterogeneous ice nucleation, yet the importance of INPs from anthropogenic sources remains poorly understood. This manuscript investigated INP concentrations ( $N_{\text{INP}}$ ) and ice nucleation active site density (ns) of immersion mode INPs in Taiyuan, China based on one month-long winter field observations. The results indicated that the temporal variability of INP concentrations is dominated by episodic natural desert dust transport, and the direct impact of anthropogenic emissions on INP loading remains limited. Namely, this study implied that in heavily polluted environments, natural dust rather than human activity governs cloud freezing processes. These findings would offer observational constraints for improving INP parameterizations in chemical transport and climate models.

In general, I think the research goal of this manuscript is clear, and the structure and results are reasonable. Therefore, I recommend this manuscript is accepted and published in the journal of *EGUsphere* after some revisions. The authors are advised to consider the following comments.

***Specific comments:***

**(1) Page 1, Abstract, Lines 18-19:** ‘CI: 6.64-8.41, CI: 1.58-1.99’.

**Comment:** When an English abbreviation first appears in the manuscript, please provide its full form.

**(2) Page 1, Abstract, Lines 22-23; Page 6, 2.2.5 Positive matrix factorization (PMF), Lines 179-186:** ‘Positive matrix factorization (PMF) identified five  $\text{PM}_{2.5}$  sources: coal combustion and traffic emissions, industry, (anthropogenic) dust, secondary aerosols and fireworks.’

**Comment:** How did the PMF method distinguish between natural dust and anthropogenic dust? Please provide a detailed description in the context. This is of great significance for the analysis of how the two different types of dust affect the INPs in the manuscript.

**(3) Page 1, Abstract, Lines 26-27 and in the context:** ‘Observed  $N_{\text{INP}}$  variability is likely governed by the interplay of episodic coarse-mode inputs and atmospheric processing rather than a single dominant source’.

**Comment:** In the manuscript, the authors only provided one month-long winter field observations in Taiyuan, which is insufficient to confirm this conclusion. That is, this conclusion is difficult to convince the readers.

**(4) Page 3, Lines 69-71:** ‘Furthermore, the influence of dust in cities is not limited to long-range natural transport; anthropogenic dust-such as agricultural operations, construction, and other urban processes-can also contribute substantially to atmospheric INPs in urban and peri-urban regions (Chen et al., 2024)’.

**Comment:** The main conclusion of this manuscript seems to be in contradiction to the results obtained by Chen et al. (2024). In order to facilitate readers' understanding, please provide a reasonable explanation in the context.

**(5) Page 4, Lines 100-102:** ‘In addition, a two-channel sampler was used to collect particles on filters for INP measurement. INP filter samples .....using a two-channel sampler without a cyclone, from 4 December 2023 to 5 January 2024’.

**Comment:** What is the meaning of ‘using a two-channel sampler without a cyclone’? Please provide the measurement particle size ranges of INP in the context, which is vital to the analysis of the results in this manuscript.

**(6) Page 9, Lines 251-253:** ‘Chen et al. (2024) found that anthropogenic dust particles, such as road dust influenced by traffic emissions, are important INP sources in the urban atmosphere. This implies that the INPs observed in Taiyuan may also influenced by anthropogenic dust particles’.

**Comment:** The conclusion of ‘This implies that the INPs observed in Taiyuan may also influenced by anthropogenic dust particles’ seems to be in contradiction to the main conclusion of the manuscript ‘In summary, long-range mineral dust transport is the decisive driver of INP enhancements, while traditional anthropogenic fine aerosols contribute minimally’ (**Abstract, Lines 25-26**). Please provide a reasonable explanation in the context.

**(7) Page 11, Lines 298-300:** ‘This comparison suggests that, under East Asian desert dust transport regime, typical atmospheric aging does not significantly modify the surface ice-nucleating activity of mineral dust, and that mineralogical composition and particle-size characteristics are likely more important determinants’.

**Comment:** The author didn't provide direct and sufficient evidences in the

manuscript to prove this conclusion. Please revise this conclusion or provide sufficient evidence in the manuscript. For instance, ‘typical atmospheric aging does not significantly modify the surface ice-nucleating activity’, the authors didn’t provide the ‘typical atmospheric aging processes’ or ‘aging mineral dust aerosol’ in the context.