

1 *Supplement of*

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# 3 **Dust Transport and Local Anthropogenic Emissions Differently** 4 **Shape Atmospheric Ice-Nucleating Particles: Insights from an** 5 **Industrial Urban Atmosphere**

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## 16 **1. Supplementary Tables**

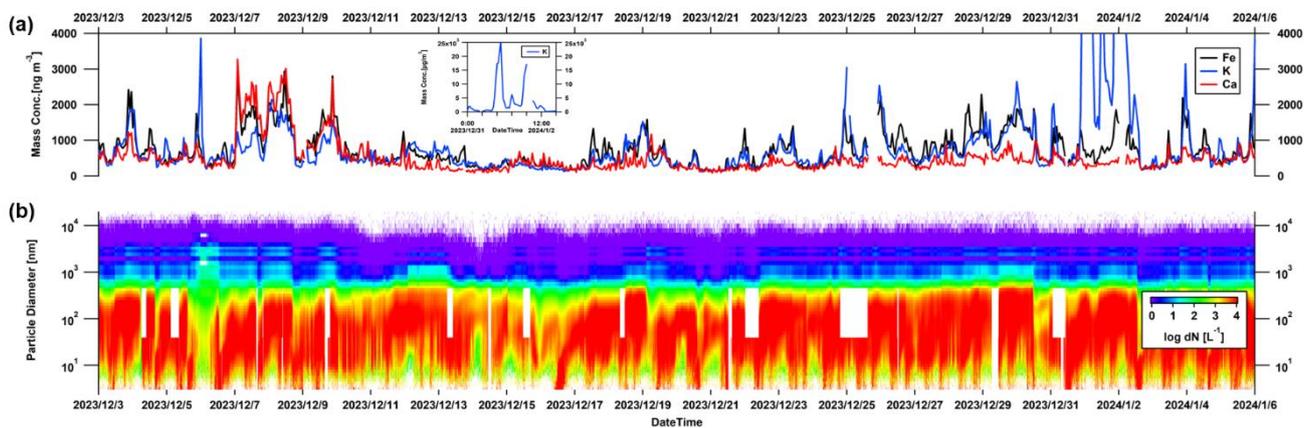
17 **Table S1.** The Pearson correlation coefficients between pollutants and the measured  $N_{\text{INP}}$  at different temperatures are  
18 presented, with significant results at the 95% confidence level ( $p < 0.05$ ) highlighted in bold. “HM” is the sum of 8 PM<sub>2.5</sub>-  
19 bound heavy metals (Cd, Cr, Hg, As, Pb, Cu, Zn, Ni).  $N_{>0.5\mu\text{m}}$ ,  $N_{<1\mu\text{m}}$ , and  $N_{>1\mu\text{m}}$  refer to the particle number concentrations  
20 with diameters larger than 0.5  $\mu\text{m}$ , smaller than 1  $\mu\text{m}$ , and larger than 1  $\mu\text{m}$ , respectively.

Factors	-10 °C	-12.5 °C	-15 °C	-17.5 °C	-20 °C
Fe	0.22	0.13	0.14	0.05	-0.20
K	-0.01	0.17	0.02	-0.11	-0.06
Ca	<b>0.44</b>	0.27	0.33	0.33	0.08
Zn	0.12	0.16	0.14	-0.02	-0.19
Pb	0.32	0.38	0.34	0.29	0.10
Mn	0.10	0.09	0.13	-0.01	-0.28
Cu	-0.03	0.15	0.01	-0.10	-0.07
As	0.17	0.11	0.11	-0.01	-0.12
Ag	-0.04	-0.12	-0.08	-0.03	0.27
Ga	0.11	0.11	0.14	-0.03	-0.05
Cr	-0.03	-0.09	-0.12	-0.21	-0.39
Se	0.12	0.10	0.08	-0.11	-0.12
Co	<b>0.61</b>	<b>0.61</b>	<b>0.45</b>	0.38	0.22
Sr	-0.03	0.15	0.00	-0.12	-0.05
Cd	-0.06	-0.05	0.00	0.02	0.03
Ba	-0.02	0.15	0.00	-0.10	-0.05
Hg	0.12	0.19	0.16	-0.09	-0.19
Ni	-0.12	-0.18	-0.09	-0.25	<b>-0.41</b>
Au	<b>-0.49</b>	<b>-0.50</b>	<b>-0.44</b>	-0.27	-0.07
NO <sub>3</sub> <sup>-</sup>	0.06	-0.03	-0.02	-0.16	-0.18
SO <sub>4</sub> <sup>2-</sup>	0.04	-0.01	-0.02	-0.20	-0.17

$\text{NH}_4^+$	0.07	0.00	0.00	-0.17	-0.19
$\text{Cl}^-$	0.11	0.19	0.16	-0.06	-0.24
$\text{K}^+$	-0.01	0.16	0.02	-0.11	-0.08
$\text{Na}^+$	0.01	0.04	0.18	0.00	-0.34
$\text{Mg}^{2+}$	0.05	0.22	0.07	-0.06	-0.08
$\text{Ca}^{2+}$	0.22	0.23	0.30	0.33	-0.16
$\text{SO}_2$	-0.08	-0.03	0.10	0.05	-0.33
$\text{HNO}_2$	0.23	0.22	0.18	0.07	-0.08
$\text{HNO}_3$	0.17	0.09	0.09	-0.02	-0.04
$\text{NH}_3$	0.39	0.32	0.25	0.14	-0.01
$\text{HCl}$	-0.10	-0.03	0.03	-0.02	-0.25
$\text{OC}$	0.23	0.16	0.23	0.03	-0.13
$\text{EC}$	0.17	0.11	0.18	0.03	-0.18
$\text{PM}_{10}$	0.17	0.12	0.14	-0.02	-0.20
$\text{PM}_{2.5}$	0.11	0.08	0.07	-0.12	-0.18
$\text{HM}$	0.06	0.19	0.08	-0.07	-0.14
$\text{N}_{>0.5\mu\text{m}}$	-0.03	-0.06	-0.07	-0.15	-0.16
$\text{N}_{<1\mu\text{m}}$	-0.15	-0.15	-0.07	0.00	-0.33
$\text{N}_{>1\mu\text{m}}$	0.10	0.04	0.05	-0.01	-0.21

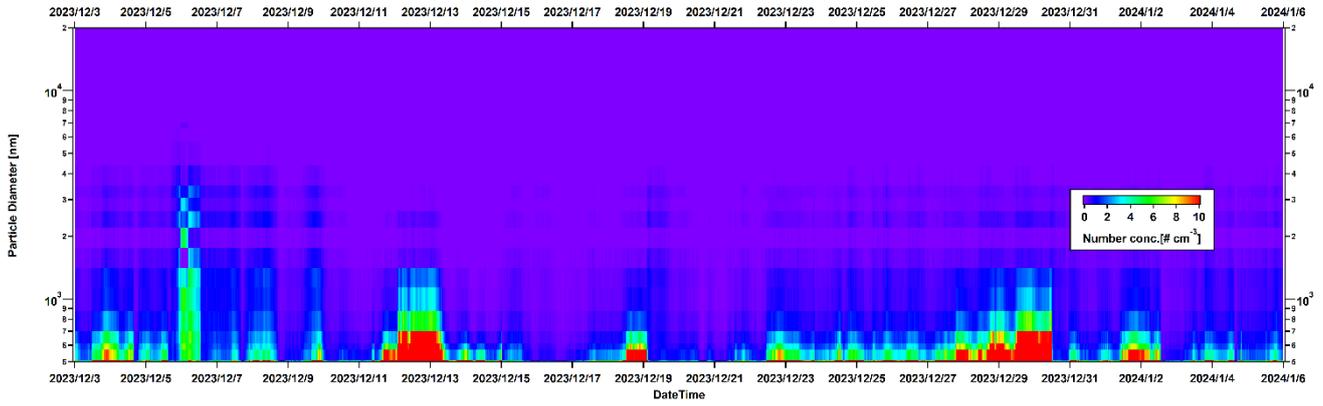
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## 22 2. Supplementary Figures



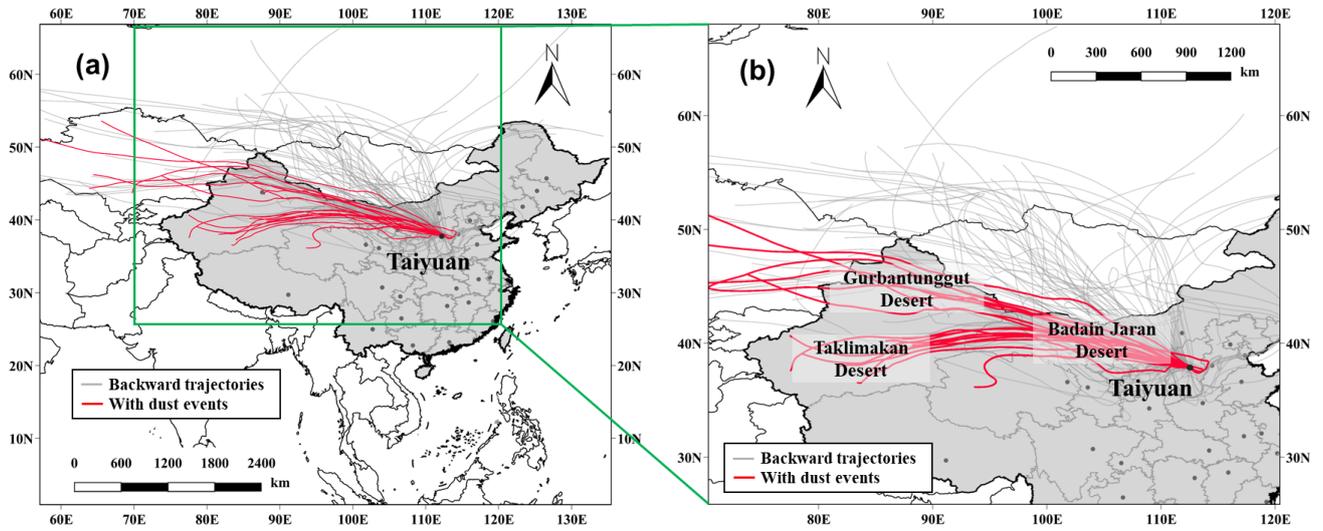
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24 **Figure S1.** Time series of aerosol physicochemical parameters observed in Taiyuan from December 2023 to January 2024. (a) Mass  
 25 concentrations of representative metallic elements (Fe, K, Ca) measured by XRF. (b) Particle number size distributions (PNSD) obtained  
 26 from SMPS and OPC measurements.



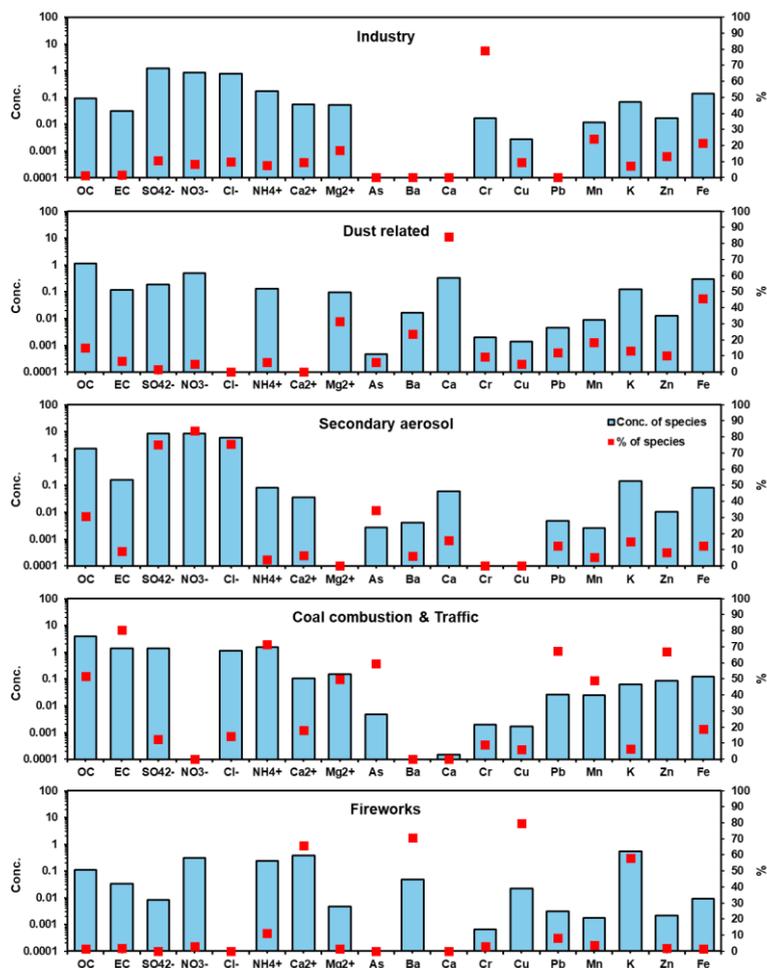
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28 **Figure S2.** Particle number size distribution (PNSD) for particles larger than 500 nm.



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30 **Figure S3.** 72-hour backward trajectories of air masses at different scales. (a) All backward trajectories (in gray) during the observation  
 31 period, along with the results of trajectory clustering. (b) Backward trajectories during the dust transport episode, highlighted in red, with  
 32 the locations of the three major deserts in northwestern China indicated.

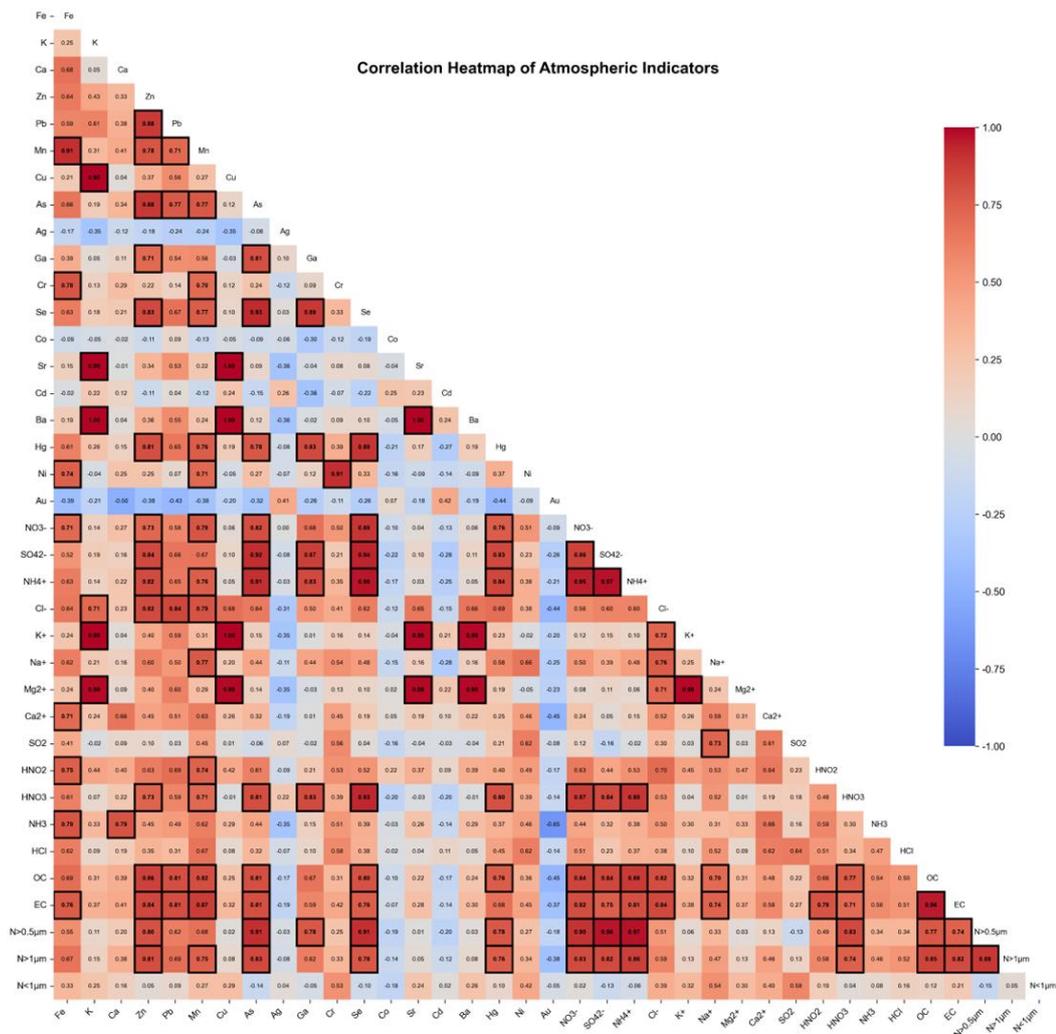


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34 **Figure S4.** PMF Factor profiles for ambient PM<sub>2.5</sub> in Taiyuan.

35 Five factors were identified in the PMF analysis to resolve the sources and contributions of PM<sub>2.5</sub>, with the resulting factor  
 36 profiles and contributions shown in Fig. S4. Factor 1 showed high contributions of Cr and Mn, where Cr is mainly emitted  
 37 from coal combustion and metallurgical industries such as steel production (Song and Gao, 2011), while Mn is associated with  
 38 metal smelting and manufacturing processes (Zheng et al., 2014). Considering the developed metallurgical, chemical, and coal  
 39 industries in Taiyuan (Tang et al., 2014), this factor was identified as industrial emissions. Factor 2 was dominated by Ca and  
 40 Fe, both crustal elements closely related to dust and resuspended (soil) dust particles (Chen et al., 2024; Huy et al., 2020; Lin  
 41 et al., 2015) and thus was attributed to dust-related sources. Factor 3 exhibited high loadings of SO<sub>4</sub><sup>2-</sup>, NO<sub>3</sub><sup>-</sup>, and Cl<sup>-</sup>, with a  
 42 moderate contribution from OC, and was interpreted as secondary aerosols, comprising both secondary inorganic and organic  
 43 components (Hopke et al., 2020; Srivastava et al., 2021). Factor 4 was enriched in Zn, Pb, Mn, As, EC and OC. Zn and Mn  
 44 are tracers for vehicle exhaust and brake or tire wear (Yatkin and Bayram, 2007), Pb has multiple origins including vehicular  
 45 emissions (Smichowski et al., 2007; Srivastava et al., 2021). EC, OC and As are all recognized tracers of coal combustion

46 (Oros and Simoneit, 2000; Srivastava et al., 2021). Therefore, this factor was identified as a mixed source associated with coal  
 47 combustion and traffic emissions. Factor 5 was characterized by high Cu, Ba and K loadings, elements commonly used as  
 48 additives in fireworks to produce colored flames (Rocco et al., 2025). The elevated K levels likely originate from potassium  
 49 salts which serve as common oxidizers in pyrotechnic formulations (Martín-Alberca and García-Ruiz, 2014). This factor was  
 50 therefore identified as a fireworks-related source. The correlation heatmap (Fig. S5) also reveals strong correlations among  
 51 certain species, such as Cu, Ba, and Sr (fireworks); Mn and Fe (industrial); and Zn and Pb (traffic), which may corroborate the  
 52 source assignments.



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54 **Figure S5.** Heatmap of correlation analysis for various atmospheric species. Correlation coefficients (R) are indicated numerically and by  
 55 color (sample size n = 25).

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