

Response to Reviewer # 1 (RC2)

Manuscript title: Emission control redirects aerosol formation toward nocturnal oxidant chemistry: Observations at a Korean petrochemical complex

Manuscript ID: egusphere-2026-2795

We appreciate the anonymous reviewer for the thoughtful review and constructive comments. We have carefully considered every suggestion and revised the manuscript accordingly. In the reply that follows, reviewer comments are shown in blue, our responses are in black, and manuscript modifications are shown in red, with the revised text quoted verbatim so that the referee can see exactly how each change appears. Line and section references correspond to the revised manuscript.

General comments:

Kim et al. present an interesting study on the transition from daytime photochemistry to nighttime chemistry based on comprehensive field observations conducted at the Daesan Petrochemical Industrial Complex. The authors demonstrate that under the emission-control strategy, the daytime NO titration effect is weakened, allowing O₃ to accumulate and thereby enhancing nighttime nitrate and SOA formation. The study provides valuable insights into the atmospheric chemical response to NO_x emission reductions and has important implications for future air pollution control strategies. Overall, the manuscript is well organized and suitable for publication in ACP after minor revision. The following comments should be addressed before publication.

We sincerely thank the referee for the encouraging assessment of our study and for recognizing its implications for future air pollution control strategies. We are especially grateful for the recommendation for publication after minor revision. We have carefully addressed all specific comments below, and we believe the revisions substantially strengthen both the clarity of the presentation and the interpretation of the results.

Specific comments:

Lines 14–15: Does the reported concentration refer to PM₁ or PM_{2.5}? Please clarify.

The reported concentration refers to submicron aerosol (PM₁), as noted in the text.

Lines 19–20: The reported correlation appears to result from the co-production of gas- and particle-phase species. However, the underlying mechanisms during daytime and nighttime may differ substantially. In particular, nighttime O₃ and NO₂ chemistry is driven by different oxidation pathways than daytime photochemistry. Although similar correlations are observed, the associated chemical mechanisms may not be the same. Please clarify this point.

We fully agree with the referee and thank them for raising this important point. The underlying oxidation pathways do differ substantially between the two periods: daytime chemistry is initiated primarily by OH generated from photolysis, whereas nighttime chemistry is dominated by NO₃ radicals produced via NO₂ + O₃ → NO₃ + O₂ and by N₂O₅ heterogeneous uptake on aqueous particle surfaces (Brown and Stutz, 2012; Wang et al., 2017). Our use of Ox (= O₃ + NO₂) was not intended to imply a single mechanism, but as an integrated proxy for the total oxidative capacity of the atmosphere, comparable across the day/night transition even though the specific oxidants that carry it (OH by day, NO₃ by night) differ. The comparable day–night Ox–MO/OOA correlations ($r = 0.52$ vs $r = 0.53$) therefore indicate that both regimes efficiently

convert this oxidative capacity into oxidized organic aerosol mass, not that they share a single mechanism. To make this distinction explicit, we have added a clarifying statement in Section 3.3.

Now, the relevant section reads: *“We emphasize that the comparable day–night correlations between Ox and MO-OOA reflect similar bulk oxidative capacity, not identical chemical mechanisms. Daytime oxidation is primarily initiated by photolytically generated OH, while nocturnal oxidation proceeds through NO₃-initiated pathways and N₂O₅ heterogeneous uptake (Brown and Stutz, 2012; Wang et al., 2017).”*

Line 25: Please provide the full name of VOCs when it first appears. The same should be done for other abbreviations throughout the Abstract.

We have spelled out the full names for VOCs and all other abbreviations upon their first appearance in the revised Abstract.

Line 59: It would be helpful to provide additional background information on the emission-control strategy, including its implementation and achievement.

We thank the referee for this constructive suggestion. To provide readers with the necessary regulatory context, we have added a concise passage to the Introduction. It notes that South Korea has progressively tightened industrial emission limits since the late 2010s under national air-quality management plans, that compliance is monitored in real time through the national Tele-Monitoring System (TMS) for major primary pollutants (PM, SO₂, NO_x, CO, NH₃), and that this framework has been effective at reducing direct emissions of the regulated species. Reactive VOCs and the secondary products of their atmospheric oxidation are not captured by this monitoring framework, which motivates the process-level focus of the present study. The description has been kept intentionally brief to preserve the manuscript’s focus on the atmospheric-chemistry response rather than on detailed policy evaluation. A concise passage has been added in the Introduction describing the emission-control framework and its scope.

Now, the relevant section reads: *“To manage pollutant releases, continuous monitoring is conducted through the national Tele-Monitoring System (TMS), which tracks major primary pollutants such as PM, SO₂, NO_x, CO, and NH₃ in real time (Corporation, 2024). While this system has been effective in reducing directly emitted pollutants, it does not account for non-regulated precursors such as VOCs and semi-volatile organics, nor for the secondary products arising from their oxidation.”*

Lines 83–86: The final paragraph of the Introduction does not appear to follow the standard format recommended by ACP. Please revise it to comply with the journal style.

We thank the referee for pointing this out. The final paragraph of the Introduction has been fully restructured to follow the ACP standard format: (i) a clear statement of the research gap and objectives, (ii) a description of the approach and methods, (iii) a summary of the main findings, and (iv) their implications. Numbered objectives (1)–(3) are used to make the structure explicit, and the paragraph now closes with the broader implications for industrial air-quality management.

Now, the relevant section reads: *“To address this gap, we conducted the first high-resolution, real-time characterization of submicron aerosol composition within the Daesan Petrochemical Industrial Complex during winter 2023–2024. Measurements using a High-Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS), combined with gas-phase and meteorological observations, provide direct insight into the processes governing oxidant-driven secondary formation. By integrating chemical composition, source apportionment via Positive Matrix Factorization (PMF), and meteorological analysis, we aim to (1) characterize the composition and sources of aerosols; (2) elucidate the mechanisms linking*

NO_x reduction to oxidant redistribution; and (3) distinguish between physical accumulation and active chemical production during stagnation episodes using meteorological normalization. The results reveal a regime shift in industrial atmospheric chemistry, from a photochemistry-driven daytime state to a nocturnal, titration-suppressed state, where O₃ and NO₃ radicals govern both nitrate and SOA formation."

Line 100: Please specify the time resolution for each measurement mode.

We apologize for any lack of clarity. We have explicitly stated in the revised manuscript that a time resolution of 3 minutes was applied for each.

Line 145: Please use a consistent abbreviation for HR-ToF-AMS throughout the manuscript.

We thank the reviewer for pointing this out. We have revised the manuscript to ensure that the abbreviation "HR-ToF-AMS" is used consistently throughout the text.

Line 190: Does the reported aerosol concentration include black carbon (BC)?

Yes, the reported aerosol concentration includes black carbon (BC). We have clarified this in the text by specifying it as "NR-PM1 + BC."

Line 193: Please provide a brief description of the emission-control strategy and its expected impacts so that readers can better understand the background of this study.

We appreciate the reviewer's comment. In South Korea, industrial NO_x emission limits were tightened primarily to suppress secondary aerosol formation via atmospheric reactions. However, our study aims to demonstrate that simply lowering emission limits may face limitations in certain chemical regimes, rather than providing an in-depth policy evaluation. To maintain the focus on atmospheric chemical processes, we have kept the policy details minimal while briefly clarifying this context in the revised manuscript.

Line 194: Please provide appropriate references to support this statement.

Kwon, S., Won, S. R., Lim, H. B., Hong, S. C., Lee, Y. M., Jung, J. Y., Choi, S.-D., Lee, S.-J., Oh, S., Kim, J. Y., Kim, Y. P., Shin, H. J., & Lee, J. Y. (2023). Relationship between PM1.0 and PM2.5 in urban and background areas of Republic of Korea. *Atmospheric Pollution Research*, 14(9), 101858. <https://doi.org/10.1016/j.apr.2023.101858>

Lines 200–201: If this PMF factor is strongly associated with waste incineration emissions, its current name may not accurately represent its source. Please provide additional evidence and references supporting the current source attribution.

We appreciate the referee's careful reading. The SFOA (Solid Fuel Organic Aerosol) factor was named on the basis of three converging lines of evidence: (i) the dominant mass-spectral signatures at m/z 60 and 73, which are the established AMS tracers of solid-fuel combustion (Cubison et al., 2011; Ng et al., 2011); (ii) a strong correlation of this factor with particulate chloride ($r = 0.73$), which is characteristic of coal and other solid-fuel combustion emissions in East Asian industrial settings; and (iii) directional (polar-plot) analysis (Fig. S6) showing that SFOA enhancements were associated with wind sectors corresponding to the industrial complex rather than residential areas. That said, a minor contribution from industrial waste incineration, which shares some spectral features with solid-fuel combustion, cannot be fully ruled out from the current dataset. Section 3.1 has been revised to make this partial ambiguity explicit while retaining the "SFOA" nomenclature for consistency with the AMS literature.

The Section 3.1 discussion of the SFOA factor now includes the additional mass-spectral, tracer, and directional evidence.

Now, the relevant section reads: *“Notably, solid fuel OA (SFOA) accounted for 21% of OA. Given the industrial setting and the strong correlation with chloride ($r = 0.73$) and industrial VOC tracers (Fig. S9, S10e-f), this factor is likely linked to industrial waste incineration or solid-fuel boilers within the complex, rather than residential wood burning (S1).”*

Section 3.2: This is the core section of the manuscript and provides a clear explanation of the transition from daytime photochemistry to nighttime chemistry. The discussion of qualitative contribution of nighttime chemistry to nitrate formation may be useful.

We are grateful to the referee for this positive assessment and, in particular, for the suggestion to strengthen the quantitative treatment of nighttime chemistry, which we agree is essential for the core section. Section 3.2 has been expanded on three complementary fronts. First, we now calculate and report the campaign-averaged nighttime NO_3 radical production rate $p(\text{NO}_3) = k(\text{T})[\text{NO}_2][\text{O}_3]$ using the temperature-dependent rate constant of Atkinson et al. (2004), yielding $p(\text{NO}_3) = 5.3 \times 10^6 \text{ molecule cm}^{-3} \text{ s}^{-1}$ (equivalent to 0.72 ppb h^{-1}), comparable to values reported for other polluted continental sites (Tham et al., 2016). Second, we perform a mass-balance estimate: integrating this production rate over a 12-hour night and assuming a conversion efficiency of 10-30% from NO_3 to particulate nitrate via the N_2O_5 hydrolysis pathway (Brown and Stutz, 2012), we predict a nocturnal nitrate production of $2.4\text{--}7.1 \mu\text{g m}^{-3}$ per night, in good agreement with the observed nighttime nitrate increase of $2.2 \mu\text{g m}^{-3}$ in the diurnal composite (Fig. 4b). Third, we estimate the characteristic N_2O_5 lifetime against heterogeneous loss, $\tau(\text{N}_2\text{O}_5) = 4/(\gamma \cdot v \cdot S_a)$, which yields $\tau = 46$ minutes under the observed aerosol surface area and typical uptake coefficient ($\gamma = 0.02$; Chang et al., 2011), sufficiently short to permit substantial conversion within the nocturnal boundary layer. Together, these three lines of evidence (radical production, mass balance, and heterogeneous timescale) provide a semi-quantitative assessment that nocturnal N_2O_5 chemistry can account for a substantial fraction of the observed nitrate accumulation. We continue to frame this as semi-quantitative rather than fully quantitative because direct N_2O_5 and NO_3 measurements would be required for a rigorous determination of the effective uptake coefficient at this site; this remaining limitation is explicitly acknowledged in Section 3.5.

Now, the relevant section reads: *“Quantitatively, the campaign-averaged nighttime $p(\text{NO}_3)$ was approximately $5.3 \times 10^6 \text{ molecule cm}^{-3} \text{ s}^{-1}$ (equivalent to 0.72 ppb h^{-1}), comparable to values reported for other polluted continental sites (1.7 ppv h^{-1} at Wangdu, North China; Tham et al., 2016). Integrated over a 12-hour night, this corresponds to a total NO_3 radical production of $2.3 \times 10^{11} \text{ molecule cm}^{-3}$. Assuming a conversion efficiency of ~10–30% from NO_3 to particulate nitrate through the N_2O_5 hydrolysis pathway (a typical range for polluted, humid nocturnal boundary layers; Brown and Stutz, 2012), this yields an estimated nocturnal nitrate production of $2.4\text{--}7.1 \mu\text{g m}^{-3}$ per night, which is sufficient to account for the observed nighttime nitrate increase of $2.2 \mu\text{g m}^{-3}$ in the diurnal composite (Fig. 4b). We further estimate the characteristic N_2O_5 lifetime against heterogeneous loss as $\tau(\text{N}_2\text{O}_5) = 4/(\gamma \cdot v \cdot S_a)$, where $\gamma = 0.02$ is a typical uptake coefficient on aqueous aerosol (Chang et al., 2011; Zhang et al., 2025), $v = 231 \text{ m s}^{-1}$ is the mean molecular speed at 273 K, and S_a is the observed dry aerosol surface area. This yields $\tau(\text{N}_2\text{O}_5) = 46$ minutes, comparable to the $11.9 \pm 11.8 \text{ min}$ directly measured in urban Beijing during the 2022 Winter Olympics emission-control period (Zhang et al., 2025), and sufficiently short to allow substantial conversion within the nocturnal boundary layer.*

Line 282: PMF.

We interpreted the referee’s brief note as pointing to a typographical error at this line, where “PMF” appeared without a following space (“PMFto resolve”). This has been corrected. In addition, “Positive Matrix Factorization (PMF)” is spelled out at its first appearance in Section 2.3.2 and used consistently

thereafter, including at this line. If the referee intended a different clarification at this line, we would be happy to address it in a further revision. The typographical error "PMFto" at this location has been corrected to "PMF to."

Now, the relevant section reads: *"A companion VOC study at the same site (Hong et al., 2026) used PTR-ToF-MS measurements and PMF to resolve seven major industrial source factors at Daesan and showed that, although the terephthalic acid (TPA) production factor accounted for only ~3% of total VOC mass, it contributed ~32% of the total SOA formation potential, the largest among all resolved sources."*

Section 3.2: The relationship between VOCs and MO-OOA is interesting and provides useful information on the precursors of oxidized organic aerosol. However, oxidation of VOCs is generally expected to proceed from freshly formed LO-OOA to more aged MO-OOA. Why is no comparable relationship observed between VOCs and LO-OOA? Additional discussion would help clarify this result.

We thank the referee for this insightful question. In the classical VOC oxidation cascade, a stronger VOC-LO-OOA relationship would indeed be expected. The absence of such a relationship at Daesan reflects two site-specific factors that we now discuss explicitly in Section 3.3. First, as noted in Section 3.1, LO-OOA at Daesan does not correspond to a fresh gas-phase VOC oxidation product: it shares its dominant m/z 60 and 73 signatures with SFOA and correlates with combustion-related VOC tracers (chlorobenzene, $r = 0.63$; naphthalene, $r = 0.61$) rather than with the industrial aromatic VOCs of interest here. LO-OOA therefore represents partially oxidized emissions from the SFOA source, and the classical VOC $\rightarrow$ LO-OOA $\rightarrow$ MO-OOA cascade does not apply at this site. Second, the aromatic VOCs identified as nighttime SOA precursors, benzaldehyde and ethylbenzene, undergo rapid multi-generation oxidation with high oxygenation yields under NO₃-initiated chemistry (Ng et al., 2011; Ren et al., 2021), so the intermediate LO-OOA stage is transient and the observed correlation manifests directly between the precursor and MO-OOA (consistent with the observed O/C $\approx$ 1.0). We also acknowledge that the low ambient concentrations of VOC species most relevant to fresh LO-OOA formation further limit the statistical detectability of any VOC-LO-OOA relationship at this site.

Now, the relevant section reads: *"A natural question is why the industrial VOCs correlate with MO-OOA rather than with LO-OOA, since a classical VOC oxidation cascade would first produce a less-oxidized intermediate. Two site-specific factors explain this observation. First, as discussed in Section 3.1, LO-OOA at Daesan is not a fresh VOC oxidation product but reflects partially oxidized SFOA emissions, correlating with combustion-related VOC tracers (chlorobenzene, $r = 0.63$; naphthalene, $r = 0.61$) rather than with the industrial aromatic VOCs examined here. The classical VOC $\rightarrow$ LO-OOA $\rightarrow$ MO-OOA cascade therefore does not apply directly at this site. Second, benzaldehyde and ethylbenzene are known to undergo rapid multi-generation oxidation with high oxygenation yields, particularly under NO₃-initiated nighttime chemistry (Ng et al., 2011; Ren et al., 2021); under such conditions the intermediate LO-OOA stage is short-lived, and the correlation manifests directly between the precursor and MO-OOA (O/C = 1.0). We note that VOC concentrations relevant to fresh LO-OOA formation were low at this site, which further limits detection of any VOC-LO-OOA relationship."*

Line 320: The reference format is incorrect.

We have revised the text as suggested.

Line 325: Please provide more details about the stagnant periods discussed here. Did these periods mainly occur during nighttime? In addition, it would be useful to compare the concentrations of the major species between daytime and nighttime during these periods.

We thank the referee for this important suggestion, which we have addressed with additional analysis rather than a purely descriptive response. The four stagnant episodes (December 24, 27, 29, and January 5) were not confined to nighttime; each spanned continuous multi-day intervals of low ventilation, with both daytime and nighttime hours contributing to the elevated PM loading. To directly compare the concentrations of the major species between the two periods, we split the data for each stagnant episode into daytime (07:00–19:00 LT) and nighttime (19:00–07:00 LT), computed the mean concentrations of the chemical species (nitrate, sulfate, ammonium, HOA, SFOA, LO-OOA, MO-OOA, BC), gas-phase oxidants (O_3 , NO_2), and meteorological variables (wind speed, RH, MLH), and evaluated the night-to-day contrast. The new results are summarized in **Table S3** (day vs. night means with standard deviations) and **Figure S9** (composite diurnal cycles across the four episodes).

The main findings are as follows. Severe PM pollution during the stagnant episodes was not confined to nighttime; instead, elevated loadings were persistently maintained across both daytime and nighttime hours, with daytime means being comparable to or slightly higher than nighttime means. Secondary inorganic species, including nitrate (19.94 ± 3.89 vs. $15.77 \pm 8.88 \mu\text{g m}^{-3}$, Day/Night ratio = 1.26) and ammonium (8.59 ± 1.91 vs. $6.56 \pm 3.30 \mu\text{g m}^{-3}$, ratio = 1.31), as well as MO-OOA (6.07 ± 3.13 vs. $4.62 \pm 2.77 \mu\text{g m}^{-3}$, ratio = 1.31), remained pronounced throughout both periods, with daytime levels drastically exceeding the campaign general background (Table 1; $2.69 \mu\text{g m}^{-3}$ for nitrate and $1.37 \mu\text{g m}^{-3}$ for MO-OOA). Primary tracers such as HOA (2.56 ± 2.24 vs. $1.54 \pm 1.69 \mu\text{g m}^{-3}$, ratio = 1.66) and BC (1.65 ± 0.72 vs. $1.23 \pm 0.73 \mu\text{g m}^{-3}$, ratio = 1.35) exhibited moderate day-to-night contrasts associated with diurnal human activities, whereas SFOA and LO-OOA displayed negligible differences (Day/Night ratio ≈ 1.03 – 1.06). Crucially, meteorological indicators exhibited virtually no diurnal variation during these episodes; the mixing-layer height remained uniformly suppressed (MLH: 451.9 ± 172.9 m in daytime vs. 448.4 ± 227.9 m at night), accompanied by sustained high relative humidity (77.0% vs. 76.4%) and calm winds (2.2 vs. 2.9 m s^{-1}). These conditions align with the comparable day–night Ox oxidation efficiencies and nocturnal $\text{NO}_3/\text{N}_2\text{O}_5$ pathways established in Sects. 3.2 and 3.3, demonstrating that persistent meteorological stagnation suppressed boundary-layer ventilation around the clock. Consequently, neither daytime nor nighttime can be singled out as the sole dominant period; rather, continuous multi-day stagnation fostered continuous multiphase secondary production and accumulation across the entire diurnal cycle.

Now, the relevant section reads:

“To clarify the temporal structure of these stagnant episodes, we compared major species and meteorological parameters between daytime (07:00–19:00 LT) and nighttime (19:00–07:00 LT) periods (Table S3, Fig. S9). The elevated loadings were not confined to nighttime; instead, severe pollution persisted across the entire diurnal cycle. Concentrations of major secondary species, including nitrate (19.94 vs. $15.77 \mu\text{g m}^{-3}$, Day/Night ratio = 1.26) and MO-OOA (6.07 vs. $4.62 \mu\text{g m}^{-3}$, ratio = 1.31), were comparable between day and night, with both significantly exceeding their general-period levels (Table 1). Meteorological indicators also showed negligible diurnal variation—mixing-layer height (451.9 vs. 448.4 m) and relative humidity ($\sim 77\%$) remained virtually identical, accompanied by calm winds throughout. These results indicate that neither daytime nor nighttime had a dominant influence over the other; rather, persistent meteorological stagnation continuously suppressed ventilation and sustained active secondary production around the clock.”

Table S3 Mean (± 1 standard deviation) concentrations of the major submicron aerosol species, gas-phase oxidants and meteorological variables during the daytime (07:00–19:00 LT) and nighttime (19:00–07:00 LT) hours of the four stagnant episodes (24, 27 and 29 December 2023 and 5 January 2024), pooled over the four episodes. The ratio is the daytime mean divided by the nighttime mean ; all times are local time.

Species	Unit	Daytime	Nighttime	Ratio (Day/Night)
Nitrate	$\mu\text{g m}^{-3}$	19.94 ± 3.89	15.77 ± 8.88	1.26
Sulfate	$\mu\text{g m}^{-3}$	5.74 ± 2.16	4.55 ± 2.27	1.26
Ammonium	$\mu\text{g m}^{-3}$	8.59 ± 1.91	6.56 ± 3.30	1.31
HOA	$\mu\text{g m}^{-3}$	2.56 ± 2.24	1.54 ± 1.69	1.66
SFOA	$\mu\text{g m}^{-3}$	3.00 ± 1.37	2.83 ± 2.32	1.06
LO-OOA	$\mu\text{g m}^{-3}$	6.50 ± 4.04	6.32 ± 4.59	1.03
MO-OOA	$\mu\text{g m}^{-3}$	6.07 ± 3.13	4.62 ± 2.77	1.31
BC	$\mu\text{g m}^{-3}$	1.65 ± 0.72	1.23 ± 0.73	1.35
O ₃	ppb	35.8 ± 14.1	35.3 ± 10.4	1.01
NO ₂	ppb	23.7 ± 9.2	18.4 ± 10.6	1.28
WS	m s^{-1}	2.19 ± 1.15	2.89 ± 1.87	0.76
RH	%	77.0 ± 7.9	76.4 ± 6.0	1.01
MLH	m	452 ± 173	448 ± 228	1.01

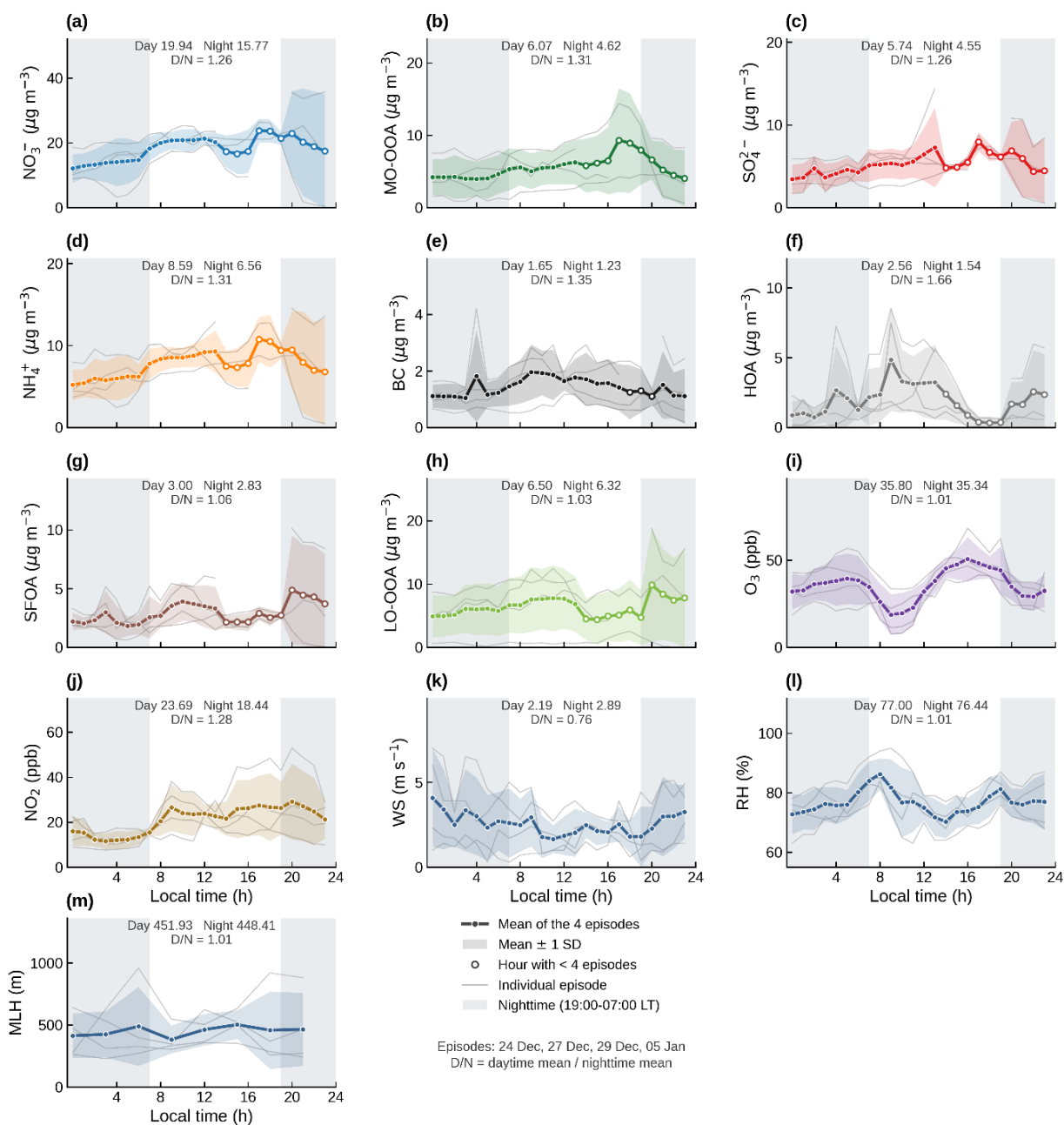


Figure S9 Composite diurnal cycles of the major submicron aerosol species, gas-phase oxidants and meteorological variables during the four stagnant episodes (24, 27 and 29 December 2023 and 5 January 2024): (a) NO_3^- , (b) MO-OOA, (c) SO_4^{2-} , (d) NH_4^+ , (e) BC, (f) HOA, (g) SFOA, (h) LO-OOA, (i) O_3 , (j) NO_2 , (k) wind speed (WS), (l) relative humidity (RH) and (m) mixing layer height (MLH). Coloured lines with symbols denote the mean of the four episodes for each hour of the day and the coloured shading denotes ± 1 standard deviation; thin grey lines show the individual episodes. Grey vertical bands mark the nighttime hours (19:00–07:00 LT) and the unshaded interval marks the daytime hours (07:00–19:00 LT); all times are local time (LT = UTC+9). Open symbols indicate hours for which fewer than four episodes provided valid data, as AMS and PMF data are missing for 14:00–19:00 LT on 27 December and for

17:00–23:00 LT on 29 December 2023; MLH is available at 3 h resolution. The values printed in each panel are the daytime and nighttime means pooled over the four episodes and their ratio (D/N, the daytime mean divided by the nighttime mean); the corresponding standard deviations, sample sizes and significance levels are given in Table S3.

Figure 2: For the time series shown in panels (i–l), several data points appear to be missing while continuous lines are still plotted. This presentation may give a misleading impression of continuous concentration changes. The missing values should be masked (e.g., as NaNs) so that discontinuities are correctly displayed.

We have revised the text as suggested.

We thank the referee once again for the constructive and thorough review. The revisions summarized above address every point raised, and we believe they substantially strengthen the manuscript.

References

- Tham, Y. J., Wang, Z., Li, Q., Yun, H., Wang, W., Wang, X., Xue, L., Lu, K., Ma, N., Bohn, B., Li, X., Kecorius, S., Groß, J., Shao, M., Wiedensohler, A., Zhang, Y., and Wang, T.: Significant concentrations of nitryl chloride sustained in the morning: investigations of the causes and impacts on ozone production in a polluted region of northern China, *Atmos. Chem. Phys.*, 16, 14959–14977, <https://doi.org/10.5194/acp-16-14959-2016>, 2016.
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- Ren, Y., Grosselin, B., Daële, V., & Mellouki, A. (2021). Reactions of NO₃ with aromatic aldehydes: gas-phase kinetics and insights into the mechanism of the reaction. *Atmospheric Chemistry and Physics*, 21, 13537–13551. <https://doi.org/10.5194/acp-21-13537-2021>