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The manuscript by Liu et al. is a solid measurement report whose main strength lies in several years of monitoring the chemical composition of aerosols at an altitude over half a kilometer above the ground. There are not many such measurements but they are important for understanding the vertical distribution of particles. From this perspective, ACP is a suitable journal for publishing this report. However, before publishing, I have a few following comments that should be addressed.

Thanks for your positive review on this work.

Discussion on the vertical mixing of pollutants due to the changes in the PBL is provided in Section 3.4. This is based on measurements of trace gases and PM_{2.5} taken at both heights (ground level and 528 m above ground level). I think it would be very useful to divide the aerosol measurements from ACSM based on whether they were above or below the PBL. Based on this, it would then be possible to interpret the impact of local and regional/LRT transport on specific measurements. Is it possible to determine the PBL height for a given measurement period (for example, using a ceilometer or at least a model) and analyze the impact of changes in the PBL on aerosol measurements at an altitude of 528 m?

Thanks for your valuable suggestion. We added the following discuss:

To better understand the vertical mixing of pollutants, we further analyzed the diurnal variations in aerosol components from October 17 to November 12, 2020. Driven by the daytime expansion of the PBL in the morning, strong vertical transport typically occurred. This process was identified by an abrupt increase in NO. Given that NO is a short-lived gaseous pollutant, its sharp increase in the 528 m layer serves as an indicator of upward transport from the surface. Based on the temporal evolution of NO, the strong vertical transport period was determined as 11:00-13:00 (Fig. S3). Accordingly, the variations in pollutants at the CITIC station during this specific period were investigated.

As illustrated in Fig. 10, the NO concentration at the CITIC station surged by 68.1% between 11:00 and 13:00, whereas SO₂ decreased by 5.9% during the same period. These observations substantiate the distinct emission sources of NO_x and SO₂ in Beijing. This divergence is further corroborated by the variations in NO₃⁻ and SO₄²⁻; NO₃⁻ increased by 21.9%, while SO₄²⁻ declined by 2.8%. Additionally, the mass concentration of Cl⁻ decreased by 7.3% during the same period, indicating its primary origin from regional transport. Although the mass concentrations of Org and NH₄⁺ also increased, their growth rates (Org: 6.3%; NH₄⁺: 11.2%) were notably lower than that of NO₃⁻, suggesting that regionally transported aerosols are particularly enriched in Org and NH₄⁺. Consequently, the downward entrainment of these regionally transported aerosols from the upper layer via PBL processes exacerbates surface air pollution in Beijing.

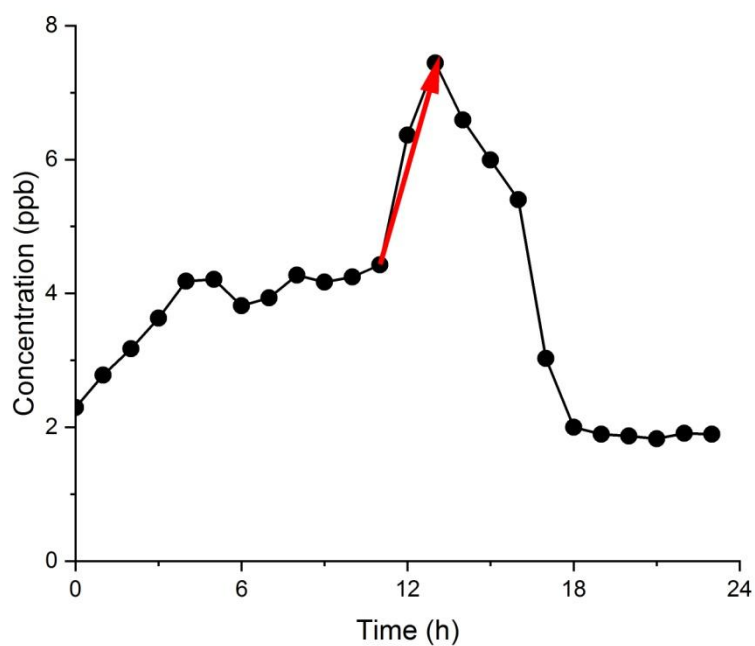


Fig. S3 The mean diurnal variation of NO at the CITIC station from October 17 to November 12, 2020. The red arrow shows the strong vertical transport period from 11:00 to 13:00.

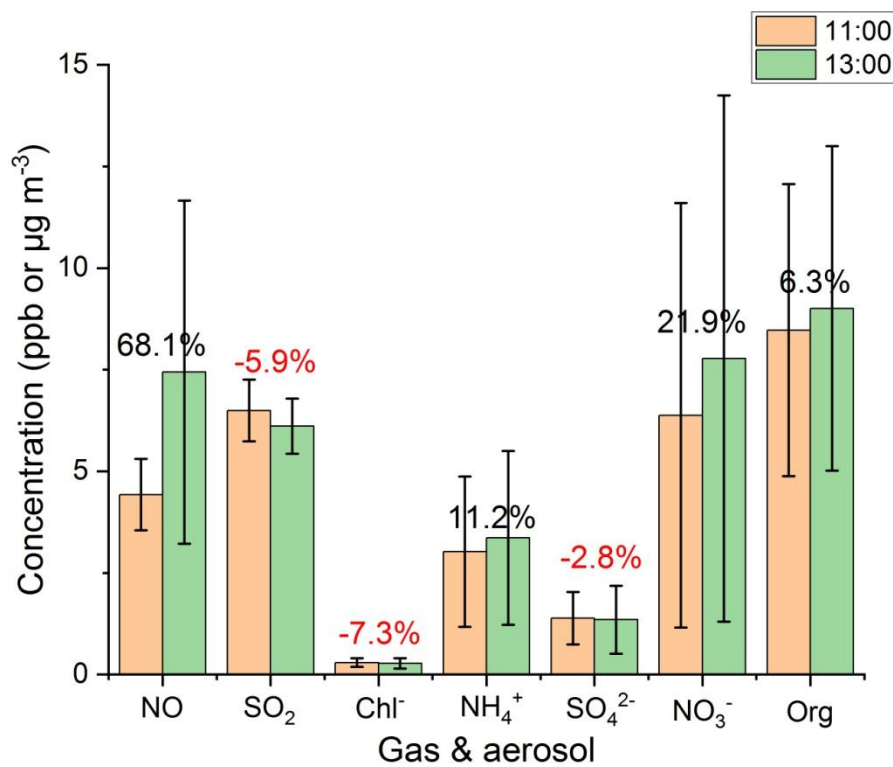


Figure 10. Mean concentrations of gases and aerosol components at the CITIC station

at 11:00 and 13:00 from October 17 to November 12, 2020. Values indicate the percentage variations of pollutants between 11:00 and 13:00. Error bars represent 50% of the standard deviations.

Furthermore, Fig. 9 shows changes in diurnal variations for PM_{2.5} and trace gases at ground level and at 528 m. Could these graphs be divided by season and included, for example, in a supplement? I would expect these variations depending on the season. Is it so?

Thanks for your suggestions. Following your suggestion, we investigated the diurnal variations of PM_{2.5} and trace gases in spring, autumn, and winter, as presented in the figures below. In general, the diurnal patterns of these pollutants were similar in the three seasons. The concentration differences between the two layers diminished during the daytime but widened at night, likely driven by the development of the PBL. Notably, SO₂ concentrations at the CITIC station peaked in autumn, which may be attributed to enhanced regional transport at this altitude.

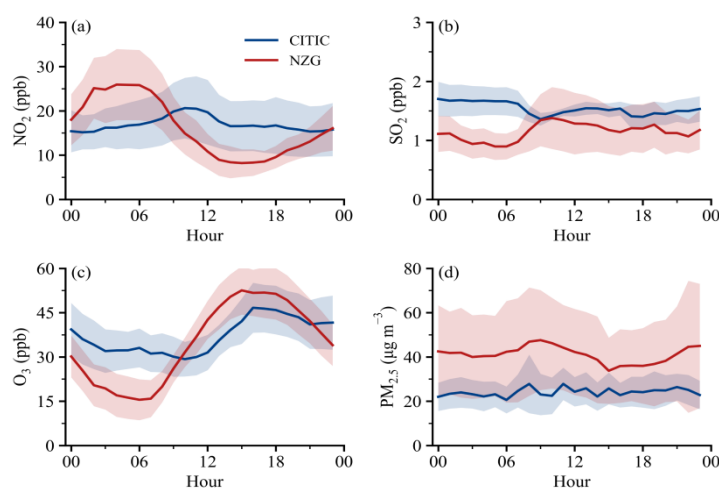


Figure a4. Diurnal variations of NO₂, SO₂, O₃, and PM_{2.5} in spring during observational period (2020-2024) at the CITIC (blue) and NZG (red) stations, respectively. The shaded areas denote 50% standard deviation.

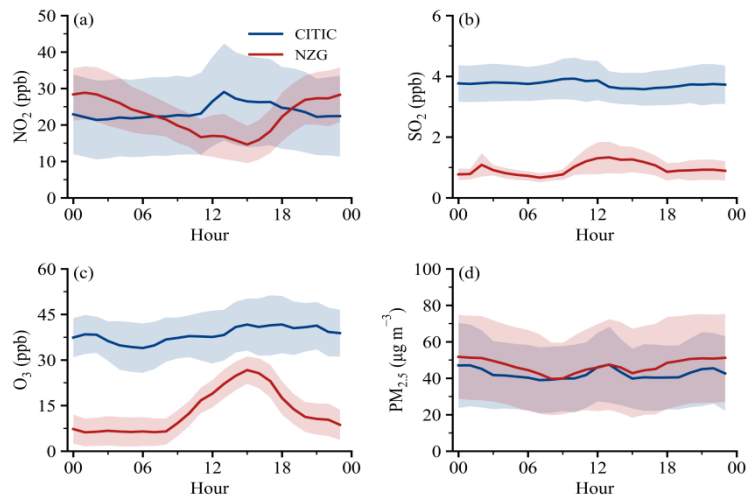


Figure a5. Diurnal variations of NO_2 , SO_2 , O_3 , and $\text{PM}_{2.5}$ in autumn during observational period (2020-2024) at the CITIC (blue) and NZG (red) stations, respectively. The shaded areas denote 50% standard deviation.

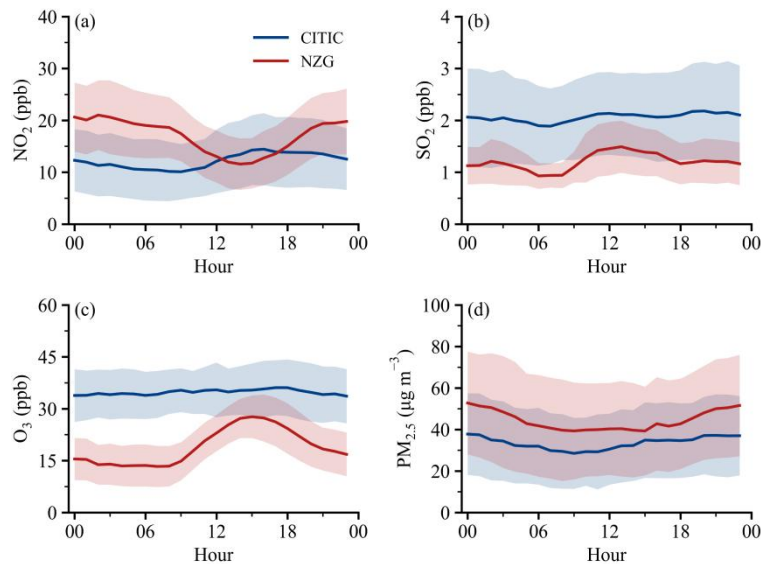


Figure a6. Diurnal variations of NO_2 , SO_2 , O_3 , and $\text{PM}_{2.5}$ in winter during observational period (2020-2024) at the CITIC (blue) and NZG (red) stations, respectively. The shaded areas denote 50% standard deviation.

The summer months (June–August?) are not so well represented. There are even no data at all for August. It would be appropriate to explain why this data is missing for the summer and to further consider how representative this data is for the discussion in Section 3.3 (seasonal aerosol composition). Yes, concentrations are lowest in the summer, but this is based solely on data from 36 days in the summer of 2023. This is then compared with other seasons, where the data typically covers at least three years. The statistics used for comparison are therefore probably different.

Thanks for your concern. Our observations from 2020 to 2024 are conducted mainly in autumn and winter when air pollution in Beijing is more serious, but less in

summer, so there are less data in summer. Our observations from 2020 to 2024 were conducted mainly in autumn, winter and spring, when air pollution in Beijing is more severe. Consequently, fewer data points were collected in summer. We added the above introduction in Section 2.

What was the data coverage for the parallel measurements of NO₂, SO₂, O₃, and PM_{2.5} used for comparison at various study sites? Were only periods where measurements from ACSM were available included in the comparison, while others were excluded? For example, were trace gas data for August excluded from the overall comparison because parallel data from ACSM were missing?

Thanks for your concern. All pollutants were measured simultaneously at the CITIC station, with the same data coverage. To maintain consistency, observations at the NZG station during the same period listed in Table 1 were analyzed. We added the above introduction in Section 2.

Does Fig. 5 represent data from the ground or 528 m? Can data from the second level be added to it as well?

Thanks for your suggestion. Fig. 5 represents data from the 528 m. We clarify this in revision. We also added a figure to show data from the ground (Fig. S2). Similar pollutant variations in the six clusters were also observed at the ground-level NZG station (Fig. S2); however, the variances of NO₂ and PM_{2.5} were reduced, which is likely attributed to strong local emissions and chemical formations.

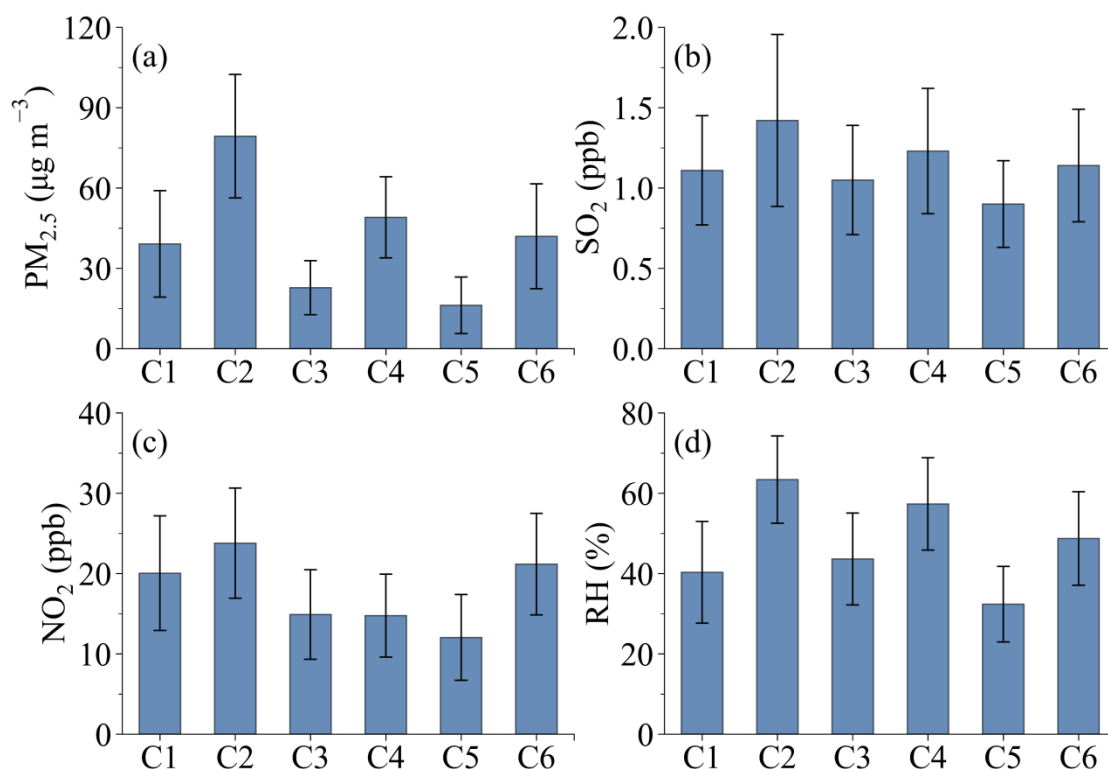


Fig. S2 Variations of PM_{2.5}, SO₂, NO₂, RH, NOR and SOR at the NZG station in the six clusters, respectively.

lines 333–335: Please develop a discussion of what these ratios imply, for example, regarding the age of the aerosol or, in more detail, the chemical reactions occurring during aerosol transport.

Thanks for your suggestion. We added the following discuss: "A higher SOR or NOR indicates a stronger conversion of SO₂ or NO_x to their particulate phase"

l. 143: instead of "a University Research Glassware (URG) cyclone to remove coarse particles with a 2.5 μm size cutoff...", I would prefer to write "and PM2.5 cyclone (by URG)"

Thanks and revised.

l. 381: correct NR-PN to NR-PM

Thanks and corrected.

Fig 4: Explain what is WPSCF?

Thanks. The WPSCF represents weighted potential source contribution function. We supplied it to Fig.4.