

Response to referee 1:

We thank the anonymous referee 1 for the supportive comments and suggestions that have improved the clarity of the manuscript. Please find below a detailed response to each suggestion. Comments by the reviewer are given in black normal font, and our response to the comments is shown in blue. Newly added and modified text in the revised manuscript and supporting information (SI) is given in italics.

This paper reports observations of HONO in a suburban location in the YRD region over a period of several weeks in summer. The authors find that photo-induced NO₂ conversion on the ground dominated the HONO production during the daytime, and NO₂ hydrolysis on the ground surface was the major source of nighttime HONO. Meanwhile, the authors employ a box model to investigate what contribution RO_x and O₃ derived from HONO makes to the radical chemistry at their measurement site. These results are meaningful for the development of HONO investigation. However, there also existed some problems the authors need to improve the manuscript before its publication in ACP.

1. I am curious about the observation time. In the Method section, the observation period is introduced to be from May 14 to June 20, 2018, but Figure 2 only presents the observed parameters from May 23 to June 18, 2018, whereas the box model simulates the period of May 28-June 12, 2018. Why?

The campaign took place from May 14, 2018, but some instruments were not in good state at the beginning. Considering the availability of complete data, we focus on the period of May 23 to June 18. As suggested, we revised the figure and showed the modeled and measured HONO profiles from May 23 to June 18.

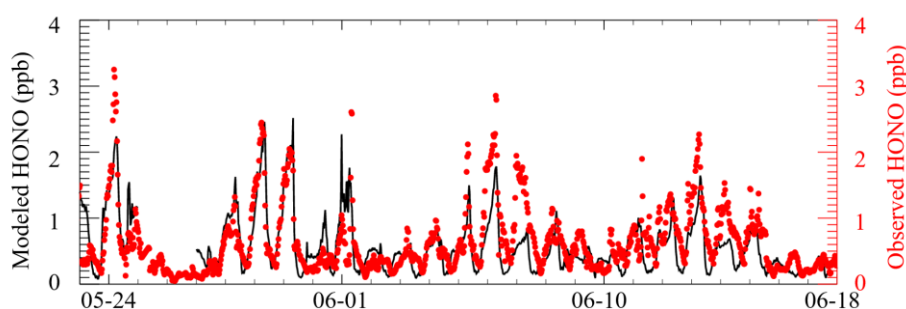


Figure 9: Time series of modeled and observed HONO concentrations from 05-27 to 06-18.

2. Importantly, in the calculation of HONO unknown source strength, the HONO deposition was not considered, why?

HONO deposition loss can be parametrized by multiplying the measured HONO concentration with the dry deposition velocity and then scaling by the boundary height.

If we take a HONO deposition velocity of 2 cm s^{-1} and a boundary height of 1000 m, HONO loss by deposition is in the order of a few ppt h^{-1} in our study which is indeed small ($<4\%$ of HONO loss by photolysis during 10:00–14:00 LT) compared to HONO loss with respect to photolysis. Therefore, for simplification, HONO loss by deposition was not considered by our study and also in some other studies when calculating the unknown source strength (Sörgel et al., 2011; Xue et al., 2022).

3. In the section of vehicle emission, the calculated average contribution of vehicle emission to observed HONO could reach 15%, but it did not appear in the HONO budget, why? According to the HONO budget result, direct emission might be the second most important source for HONO.

As suggested, we have taken vehicle HONO emission into consideration. The revised figure was shown below. HONO production by vehicle emission accounted for 22% of the seven HONO sources during nighttime, while it played a minor role during the daytime.

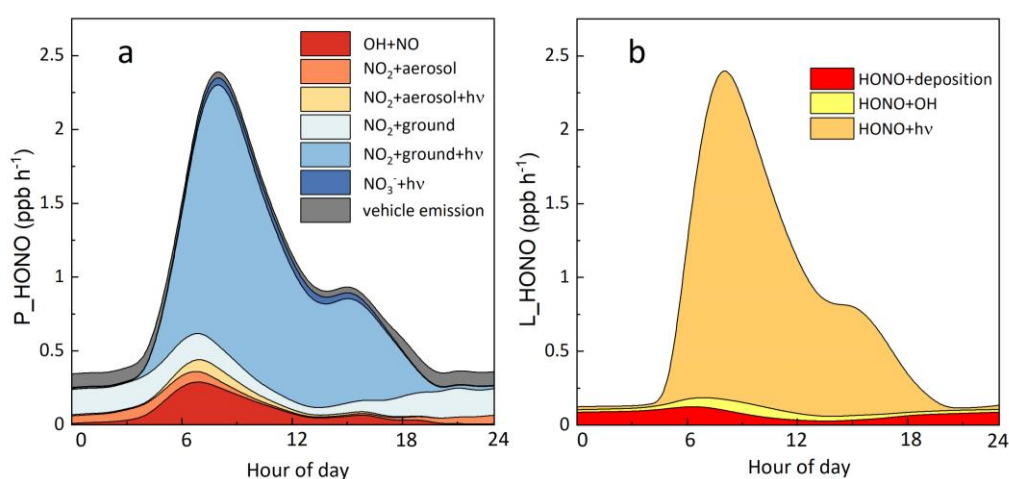


Figure 10: HONO production rates and loss rates by different pathways.

Line 2: The secondary HONO should be removed in the title.

We have removed the second “HONO” in the title.

Line 43: SOA should be presented as its full name when it appeared at the first time.

As suggested, we have changed SOA to be secondary organic aerosol (SOA).

Line 47: ...HONO was a vital OH precursor not only in the early morning but also throughout the day.

The corresponding sentence has changed as follows:

Line 48-49:

“Previous studies reported that HONO was a vital OH precursor not only in the early morning but also throughout the day.”

Line 52/87: varied – various

Changed accordingly.

Line 53: remove “to explain HONO”

Changed accordingly.

Line 76: remove “typically”

We have removed “typically”.

Line 80: heterogeneous nitrate/HNO₃ photolysis on varied surfaces – adsorbed nitrate/HNO₃ photolysis

The corresponding texts have been changed as follows:

Line 81-82:

“In addition, adsorbed nitrate/HNO₃ photolysis on various surfaces was found to be enhanced compared to gas-phase HNO₃ and also contributed to HONO formation.”

Line 82: heterogeneous – adsorbed

Changed accordingly.

Line 98/258/321/345/348/356/418/439/474: write the right format (e.g., Fu et al., (2019) found...) for the references.

Thank the reviewer for noticing the errors. We have corrected accordingly:

“Fu et al. (Fu et al., 2019)” to Fu et al. (2019)

“Liu et al. (Liu et al., 2019a)” to “Liu et al. (2019a)”

“Stemmler et al. (Stemmler et al., 2007)” to “Stemmler et al. (2007)”

“Laufs et al. (Laufs and Kleffmann, 2016)” to “Laufs et al. (2016)”

“Andersen et al. (Andersen et al., 2023)” to “Andersen et al. (2023)”

“Zhang et al. (Zhang et al., 2022b)” to “Zhang et al. (2022b)”

“Wong et al. (Wong et al., 2013)” to “Wong et al. (2013)”

“Liu et al. (Liu et al., 2021)” to “Liu et al. (2021)”

“Yang et al. (Yang et al., 2021c)” to “Yang et al. (2021c)”

Line 150: throughout the paper – in this study

Changed accordingly.

Line 155: an instrument model is needed for the portable weather station.

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Line 162: try – trying

Changed accordingly.

Line 180: the reaction of NO₂ and OH is missing in D(O_x)

Yes, we have considered NO₂+OH reaction in calculating O₃ loss rate, but missed it in the expression. The expression has corrected as follows:

Line 181-182:

$$D(O_x) = k_{O^1D+H_2O}[O^1D][H_2O] + [O_3](k_{O_3+Alkenes}[Alkenes] + k_{O_3+HO_2}[HO_2] + k_{O_3+OH}[OH]) + k_{NO_2+OH}[OH][NO_2] + 3(k_{O_3+NO_2}[NO_2][O_3] - k_{NO+NO_3}[NO_3][NO] - j_{NO_3}[NO_3])$$

Line 186/348: relative humidity has been abbreviated in line 154.

We have changed “relative humidity” to “RH”.

Line 191: it is difficult to derive the deduction of “VOCs are abundant” from “the MAXIMUM diurnal averaged HCHO concentration”. Please rephrase the sentence.

We have rephased the texts as follows:

Line 192-193:

Similar with CO, HCHO peaked around 8:00 LT with a maximum of 5 ppb, indicating the effect of anthropogenic emission-related sources.

Line 197: the Class-II limit values are corresponding to the maximum 8-hour averaged O₃, rather than O₃ concentration.

We revised the corresponding texts as follows:

Line 196-199:

“The daily maximum 8-hour average O₃ concentrations throughout the observation period frequently exceeded Class-II limit values (160 μg m⁻³, which is equivalent to 82 ppb at 298 K and 1013 kpa) of the National Ambient Air Quality Standard, and the highest O₃ concentration can reach as high as 150 ppb, indicating serious photochemical pollution.”

Line 207: What does mean the average peak concentration of OH? For example, in the study of Zhang et al., (2022a), the OH concentration of 2.7*10⁶ cm⁻³ represented the

average OH radical concentration at noontime (11:00-13:00). Comparison should be performed at the same level.

The reviewer is right. The average peak concentration means the peak OH concentration shown in the averaged diurnal profile, which typically occurred around noon. We have removed the citation of Zhang et al., (2022a).

Line 220: was possibly the reason – was the possible reason

Changed accordingly.

Line 227: need the reference for the HONO lifetime. Generally, nocturnal HONO lifetime is relatively long (several hours).

Sorry for the misleading. We mean the lifetime of HONO around noon. We have rephased the texts and add reference.

Line 225-228:

“Considering that the atmospheric lifetime of HONO is only 10-20 min around noon (with respect to photolysis) (Sörgel et al., 2011), however, the averaged noon-time HONO concentration was relatively high (0.5 ppb), which implied the existence of strong daytime HONO sources to counteract its rapid photolysis.”

Line 235: higher concentration of O₃ production – higher O₃ production

Changed accordingly.

Line 255: Jinan – Ji’nan

Changed accordingly.

Line 307: photolytic – photo-related?

Yes

Figure 2: the order of magnitude for OH is not 10⁽⁻⁶⁾ but 10⁶.

We have revised Figure 2.

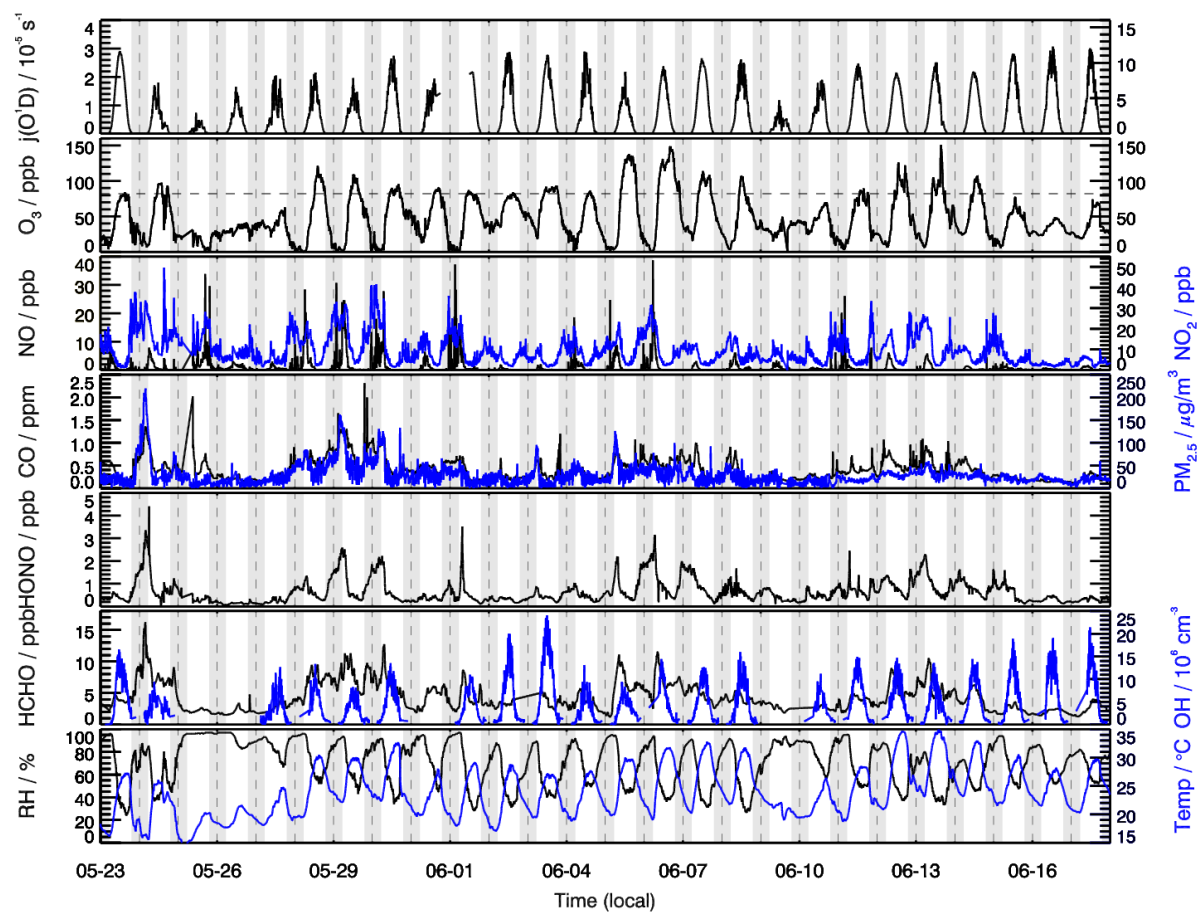


Figure 1: Time series of HONO, O₃, CO, PM_{2.5}, OH, HCHO, NO_x, relative humidity (RH), temperature and j(O¹D) during the EXPLORE-YRD campaign.

Figure 13: the meaning of legend should be stated one by one.

As suggested, the legend of Figure 13 has revised as follows:

Line

Figure 12. Model-calculated total and net O₃ production rate with and without observed HONO as a model constraint. According to different type of VOC precursors, organic peroxy radicals (RO₂) can be classified into seven categories, including methyl peroxy radicals (MO₂=CH₃O₂), first-generation peroxy radicals from alkanes (ALKAP), alkenes except isoprene (ALKEP), isoprene (ISOP), aromatics (AROP), OVOC (OVOC) and acyl peroxy radicals (ACETYLP=ACO₃+RCO₃).

Reference:

Sorgel, M., Regelin, E., Bozem, H., Diesch, J. M., Drewnick, F., Fischer, H., Harder, H., Held, A., Hosaynali-Beygi, Z., Martinez, M., and Zetzsch, C.: Quantification of the unknown HONO daytime source and its relation to NO₂, Atmos Chem Phys, 11, 10433-10447, 10.5194/acp-11-10433-2011, 2011.

Xue, C., Ye, C., Kleffmann, J., Zhang, W., He, X., Liu, P., Zhang, C., Zhao, X., Liu, C.,

Ma, Z., Liu, J., Wang, J., Lu, K., Catoire, V., Mellouki, A., and Mu, Y.: Atmospheric measurements at Mt. Tai – Part II: HONO budget and radical (RO_x+NO_3) chemistry in the lower boundary layer, *Atmos. Chem. Phys.*, 22, 1035-1057, 10.5194/acp-22-1035-2022, 2022.