**Dear Editor Dr. Graciela Raga,**

**Thank you very much for handling our manuscript. We have addressed all the comments raised by both reviewers and incorporated them in the latest manuscript.**

**Sincerely,**
**Cheng He et al.**

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**Reviewer #1**

**Comment [1-1]:** It is nice to see the probability distributions of nocturnal delta[$O_3$]/delta[t] (Figure S2). But I think you counted all nighttime delta[$O_3$]/delta[t] values so that only 7.7% of them are >5 ppb/hour. Since these 7.7% of cases are mostly out of range of two-sigma standard deviation, you think they are not likely normal fluctuations. This is better than an arbitrary threshold but still is not based on the spectrum structure, which may be driven by atmospheric processes. I am not sure if you can obtain a useful spectrum structure by only including the maximum delta[$O_3$]/delta[t] value from each night, but I think it is worth trying. If you get nothing more useful, a threshold based on Figure S2 is acceptable and at least more convincing than just following the previous studies.

**Response [1-1]: Thank you for the reply and suggestion. We have further derived the probability distributions of daily maximum nocturnal delta[O3]/delta[t]. Results are shown in Figure R1. We find that 93% of the maximum delta[O3]/delta[t] values are positive, with a peak probability in the range of 2-3 ppbv hour$^{-1}$, 5 ppbv hour$^{-1}$ places as the approximate turning point that halves the probability distribution, further supporting that the 5 ppbv hour$^{-1}$ would be an appropriate threshold.**

**We further rephrase in Section 2.3: <u>"Following previous studies of Eliasson et al. (2003) and Zhu et al. (2020), we define a nocturnal ozone enhancement (NOE) event if ozone concentration at a site increases by more than 5 ppbv ($\Delta O_3/\Delta t > 5\ ppb\ hour^{-1}$) in one of any two adjacent hours in the nighttime period. We find that nocturnal $\Delta O_3/\Delta t$ values at Chinese sites generally follow the Gaussian distribution. For all hourly nocturnal $\Delta O_3/\Delta t$ values, $\Delta O_3/\Delta t > 5\ ppb\ hour^{-1}$ cases only account for 7.7% of the $\Delta O_3/\Delta t$ dataset, indicating that this threshold should have effectively ruled out nocturnal ozone fluctuations occur under normal atmospheric conditions (Figure S2a). For the daily maximum nocturnal $\Delta O_3/\Delta t$ values only, the probability peaks in the range of 2-3 ppbv hour$^{-1}$, and the 5 ppbv hour$^{-1}$ threshold places as the approximate turning point that halves the probability distribution (Figure S2b). We thus apply the $\Delta O_3/\Delta t > 5\ ppb\ hour^{-1}$ threshold in the NOE definition."</u>**

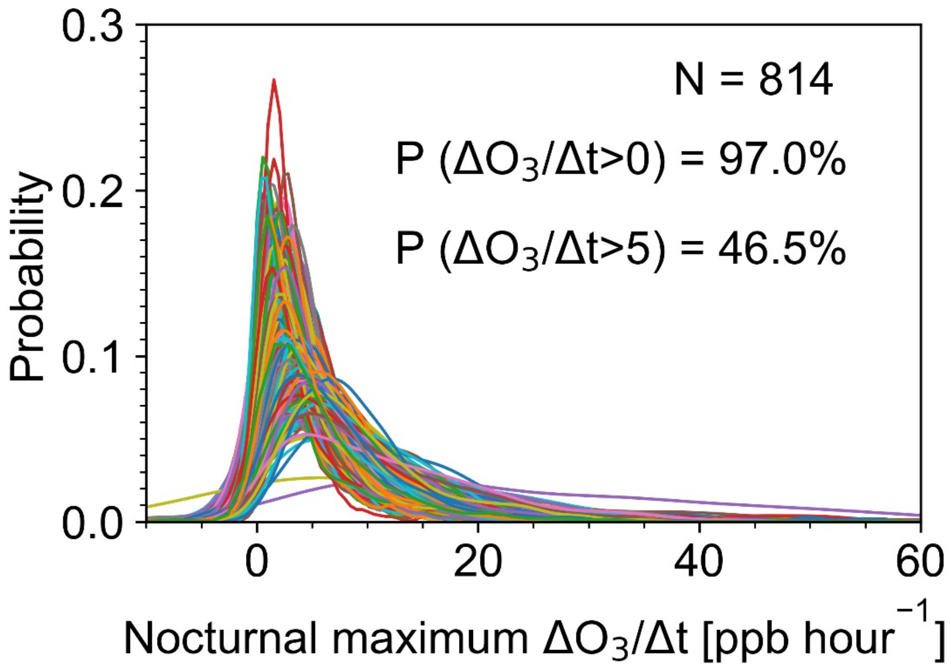


**Figure R1 Probability density distribution of daily maximum nocturnal ozone fluctuation ($\Delta O_3/\Delta t$) at all Chinese sites (represented by each curve) in 2014-2019.**

**Comment [1-2]:** Another thing I find interesting is that there are small but not negligible probabilities with substantial negative delta[$O_3$]/delta[t] values. Normally, nighttime chemistry and dry deposition cause gradual decrease of $O_3$ concentrations. However, very steep dropping of $O_3$ concentrations may occur only under some unusual atmospheric conditions. But this is out of the scope of this paper.

**Response [1-2]: Thank you for pointing it out. Nighttime titration is strong in China because of high $NO_x$ emission. The deep decrease of nighttime ozone concentrations may be related to rapid chemical loss through $NO_x$ titration. Of course, it may also be related to some unusual atmospheric conditions that effectively scavenge ozone the as the reviewer suggested. We agree that this interesting scientific question is worth studying further in the future.**

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**Reviewer #2**

**Comment [2-1]: Major comments:** The paper presents an overview of the general characteristics of nocturnal ozone enhance (NOE) events in China and tries to find possible mechanisms leading to the NOE events based on 6-year observational data from the national monitoring network of China. In general, this is an excellent and well written paper. Based on statistics on friction velocity, boundary layer height and low-level jet, the correlation between the boundary layer physical processes and the NOE events is well explained, which is of great significance for improving the scientific understanding of NOE. The reviewer noted that the author has made appropriate revisions to the paper according to the comments from other reviewers, which significantly improved the quality and publish ability of the paper. Based on the above points, the reviewer suggests accepting the paper after some minor revisions:

**Response [2-1]: We thank the reviewer for the positive and valuable comments. All of revisions have been implemented in the latest manuscript.**

**Comment [2-2]:** In the two paragraphs where Lines 280-290 are located, the explanation on the mechanism of friction velocity and PBLH causing NOE could be further enhanced: (1) The physical meaning and formula of friction velocity, and its relationship with turbulence intensity and vertical mixing. (2) The method used to calculate the PBLH (how it is derived from ERA5 model data?), the relationship between the increase of PBLH and the downward infiltration of residual layer mass.

**Response [2-2]: Thank you for pointing it out. We have modified the text to describe the meaning friction velocity and PBLH and their implication for the mechanisms. We do not calculate the friction velocity and PBLH as they are available from the ERA5 dataset.**

**We state sources of the data in Section 2.2: "<u>We apply three-dimensional fields of meteorological parameters including temperature, relative humidity, horizontal and vertical wind speed and direction on pressure levels, and two-dimensional fields of planetary boundary layer height, and friction velocity from the ERA5 dataset, i.e. the fifth generation of the European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis of the global climate (https://cds.climate.copernicus.eu/#!/home, last access: 15 April 2022)."</u>**

**We add the following statement to illustrate the relationship with increasing vertical mixing and the U* / PBLH in Line 280: <u>"The U* and PBLH are applied to assess the atmospheric turbulence capacity for the vertical mixing, transport and diffusion of air pollutants. Increasing U* and PBLH levels typically indicate enhanced turbulent kinetic energy and intensity, thus a more unstable boundary layer and stronger atmospheric mixing (Ren et al., 2021; He et al., 2022).", and in Line 289: "More importantly, we see distinct differences in their temporal evolution. U* and PBLH typically show a steady decreasing trend throughout the nighttime during NNOE events, while the U* and PBLH show increase in at least a certain part of the nighttime period in the NOE events, suggesting that atmospheric mixing and downward infiltration of residual layer mass are becoming more active (Figure 6a and 6c)."</u>**

**Reference**

Ren, Y., Zhang, H., Zhang, X., Wei, W., Li, Q., Wu, B., Cai, X., Song, Y., Kang, L., and Zhu, T.: Turbulence barrier effect during heavy haze polluti on events, Sci Total Environ, 753, 142286, 10.1016/j.scitotenv.2020.142286, 2021.

He, J. Y., Chan, P. W., Li, Q. S., Li, L., Zhang, L., and Yang, H. L.: Observ ations of wind and turbulence structures of Super Typhoons Hato and Ma ngkhut over land from a 356 m high meteorological tower, Atmospheric Research, 265, 10.1016/j.atmosres.2021.105910, 2022.

**Comment [2-3]:** It is suggested to further enhance the literature review of NOE related issues, although the current one is excellent enough. In the past few months, some new studies on the characteristics and mechanisms of nocturnal ozone pollution have been published, and some of the conclusions of these new references can also support the conclusions of this paper.

**Response [2-3]: Thank you for pointing it out. We notice that two recently published papers that systematically studied the characteristics of nocturnal ozone enhancement, and quantified the impact of vertical and horizontal transport in the PRD region. We have added them in Line 316-367.**

**Reference**

Wu, Y., Chen, W., You, Y., Xie, Q., Jia, S., and Wang, X.: Quantitative impacts of vertical transport on long-term trend of nocturnal ozone increase over the Pearl River Delta region during 2006-2019, Atmos. Chem. Phys. Discuss., 2022, 1-29, 10.5194/acp-2022-360, 2022.

Yang, H., Lu, C., Hu, Y., Chan, P.-W., Li, L., and Zhang, L.: Effects of Horizontal Transport and Vertical Mixing on Nocturnal Ozone Pollution in the Pearl River Delta, Atmosphere, 13, 10.3390/atmos13081318, 2022.

**Comment [2-4]:** Please verify or correct some minor flaws in the text editing. For example, it is recommended to change “six-year observation” to “6-year observation”. Remove the underline from the text near L400…

**Response [2-4]: Thank you for pointing it out. We corrected them accordingly.**

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**Comments from Editor Dr. Polina Shvedko:** For the next revision, please check if your figures containing maps/aerial images require a copyright statement/image credit and add it to the figures (or captions) (https://publications.copernicus.org/for_authors/manuscript_preparation.html#mapsaerials). If these figures were entirely created by the authors, there is no need to add a copyright statement or credit. In that case it is important that you confirm this explicitly by email. 2. Please ensure that the colour schemes used in your maps and charts allow readers with colour vision deficiencies to correctly interpret your findings. Please check your figures using the Coblis – Color Blindness Simulator (https://www.color-blindness.com/coblis-color-blindness-simulator/) and revise the colour schemes accordingly.

**Response: Thank you very much for the suggestion. We have revised accordingly.**