Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC1
https://doi.org/10.5194/acp-2022-310-RC1, 2022

Comment on acp-2022-310

Anonymous Referee #1

Referee comment on "The unexpected high frequency of nocturnal surface ozone enhancement events over China: characteristics and mechanisms" by Cheng He et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-310-RC1, 2022

General comments

This paper focuses on the characteristics and mechanisms of nocturnal ozone enhancement (NOE) events. Cases with surface ozone enhancement of 5 ppbv/hour or greater in one of any two adjacent hours in 20:00-06:00 LT are defined as NOE events. Frequencies of NOE events are calculated for 814 sites in China, 762 sites in the US and 1880 sites in EU countries in 2014-2019. The annual frequency of NOE events over China is found unexpectedly high (41%+/-10%) and much higher than those over the US and EU. Higher afternoon ozone levels (as proxies of nocturnal ozone levels in the residual layer) are believed to be the precondition of NOE events. It is confirmed by cases studies that the NOE events in the surface layer is triggered by enhanced atmospheric mixing during processes like convective storms and low-level jets. More NOE events are found in warm season than in cold season. Distributions of NOE events of different magnitudes over China are presented and discussed as well as the timing of NOE events and nighttime variations of ozone, NO2, CO, friction velocity and PBLH in NOE and non-NOE events in five Chinese cities.

NOE events have been found at some sites in different parts of the world and reported in the literature. Previous studies have already shown that the NOE events are caused mainly by convective storms, low-level jets, horizontal transport, etc. To the best of my knowledge, however, there has been no previous publication presenting nationwide statistics of NOE events over China or the comparison of NOE events over China with those over EU and the US. In this sense, this paper is original and within the scope of ACP. The methods applied in this paper are mostly valid. The results presented are interesting and generally sound. The paper is well structured and written. It can be improved by appropriately addressing the following issues. I recommend publication of this paper in ACP after revisions.

Specific comments:

Major comments:

- In this study, a NOE event is defined as ozone increase by at least 5 ppbv/hour in one of any two adjacent hours in 20:00-06:00 LT. The selection of the threshold (5 ppbv/hour) for NOE seems to be arbitrary. As the threshold value substantially impacts not only the statistics of NOE events but also the results like the contrasts between regions and between warm and cold seasons, it should be determined based on scientific analysis and consideration. The observations of ozone and also other species are always fluctuating in a certain degree due to factors like turbulences, source/sink disturbances, transport, etc. The intensities of fluctuations related to different factors should vary in a large range and may be dependent of season and location. I think you may obtain a kind of fluctuation intensity spectrum for each site by plotting the frequencies against the delta[O3]/delta(t) values. I do not know how the spectrum may look like but guess it might not be monotonic. If the spectrum is really not a monotonic curve, you may relatively easily determine your threshold based on your scientific considerations. Otherwise it might be difficult for you to determine the threshold and convince the readers of your threshold. I think the focus of this paper is the NOE event that is really caused by any particular atmospheric condition or process. The nocturnal ozone fluctuations occur daily under normal atmospheric conditions should not be included in the NOE statistics. In particular, when you are using "unexpected high frequency of" NOE in your title, the threshold definition must be supported by scientific analysis.
- The regional and seasonal differences in the NOE frequencies are all impressive. Data show that regions with higher frequencies of NOE events are associated with higher levels of afternoon ozone. However, the real cause of the regional and seasonal differences in the NOE frequencies is not clear. Are the NOE differences caused by the differences in atmospheric processes (convective storm, low-level-jet, etc.) or purely the ozone level differences or both? To answer this question, it is suggested to consider the relative fluctuation of nocturnal ozone (i.e., nighttime ozone enhancement normalized by the corresponding afternoon ozone level) as the metric of a NOE event (again, the threshold should be carefully determined).

Other comments:

- L110: In the abstract section the NOE event is defined as ozone increase by at least 5 ppbv/hour, meaning equal to or greater than 5 ppbv/hour. This is not consistent with > 5 ppbv/hour stated here. In addition, it is not clear which number is counted if two or more cases occur with enhancement over the threshold during one night. In other word, can the NOE event in a day be more than one?
- L176: what do you mean by "evenly distributed"? The statistics (Figure 4a) for this time period are 18%, 29%, and 19%.
- L274: I think substantial differences in the absolute values of U* and PBLH between the NOE and NNOE events are required if the NOE is really caused by enhanced vertical mixing. The differences may have been masked by averaging effect, average over six

years and different sites. Case studies using data from individual sites may make it clear.

- L280: FV or U*? Be consistent.
- L283: it is worth knowing which process is the most important one that causes the increasing atmospheric instability.
- L359-370: the case with typhoon "Fung-wong" may be more complicated than just transport of ozone-rich air in the north to the PRD region". It is known that typhoon processes may strongly impact the surface ozone level in the periphery of typhoons. Descending air usually play a key role in these processes. Even ozone in the upper troposphere and lower stratosphere can be transported down to the surface (e.g., Jiang et al., Why does surface ozone peak before a typhoon landing in southeast China?, Atmos. Chem. Phys., 15, 13331–13338, https://doi.org/10.5194/acp-15-13331-2015, 2015).
- L374-375: I think it depends highly on the timing and strength of the NOE event. Of course, it is not so simple considering the variations of ozone precursors and redistribution in the vertical direction.
- L390: the seasonal variation of surface ozone in the PRD region is much different from those in other Chinese regions. More of the NOE events in the PRD occur in cold season than in warm season. Perhaps it is better to point out this particularity.
- Figure 6: the temperature differences between NOE and NNOE events are very large. Why?