Comments Response

Journal: Atmospheric Chemistry and Physics

Manuscript ID: acp-2020-1302

Title: "Unexpected enhancement of ozone exposure and health risks during National Day in China"

Dear Referee #2,

We appreciate your comments to help improve the manuscript and tried our best to address your comments. The detailed responses and related changes are shown in below. Our response is in blue and the modifications in the manuscript are in red. All figures are included in the attached PDF file.

This manuscript investigates the causes of high O3 episode during Chinese National Day Holiday using CMAQ modeling. The high O3 concentration is found to be caused by enhanced anthropogenic emissions and regional transport. Further, the health risks of these high O3 episode are estimated based on the response function of premature mortality of O3 exposure. The scope of this manuscript is of interest and fits the Atmospheric Chemistry and Physics journal. However, the illustration of the manuscript makes it a bit difficult to review fairly. The readability can be easily improved by elaborating several key terminologies and large fonts in figures. For example, two terms "O3_VOC" and "O3_NOx" are discussed throughout the manuscript to diagnose the O3 chemistry, but they are not clearly defined in the manuscript. The font of figure 3 is too small. The color scheme in figure 4b is impossible to read. I believe this study is publishable, but requires substantial revisions.

Response: Thanks for the comments. In the revision, we tried our best to modify our manuscript, including the related figures (Figure 3 and Figure 4b) to improve our study. Below is the response to each specific comment.

1. The importance of regional transport. Look at Figure 2a CNDH, the O3 concentration is up to 100 ppb in south China sea around Hainan and it is higher than the mainland China. Is this real? If so, what's the impact of such high O3 concentration on southern China? Is this the major cause of the high O3 episode during CNDH? Figure S5 suggests the prevailing wind direction is from mainland to ocean during CNDH in CMAQ. Is this consistent with local measurements? Line 217 indicates the south wind is prevailing. I am confused.

Response: From Figure 2a and Figure S5, the high O_3 in the sea around Hainan is mainly due to the regional transport under the impact of the north wind. The O_3 observation data in the south China sea is not available, so we couldn't further evaluate the O_3 level in the ocean. While Table S5 and Figure 2a showed our predicted O_3 agreed well with the observed O_3 throughout China, which could provide robust results for the air quality analysis. Our study also concluded that the regional transport corresponds to the elevated O_3 during the CNDH (in section 3.3). In addition, we also compared the observed and predicted wind field in the key cities (Guangzhou and Shenzhen; Zhuhai's data was not available) in the attached PDF file (Figure R2-1 and R2-2). It is shown in Figures R2-1 and R2-1 that the prevailing wind direction is north, which is consistent with the prediction. The line 217 should be "north wind". Sorry for the mistake and we have corrected it in the revised manuscript.

Changes in manuscript: (line 236-238) The SOU sector is the most crucial contributor among all these regional sectors outside Guangdong due to the prevailing north wind.

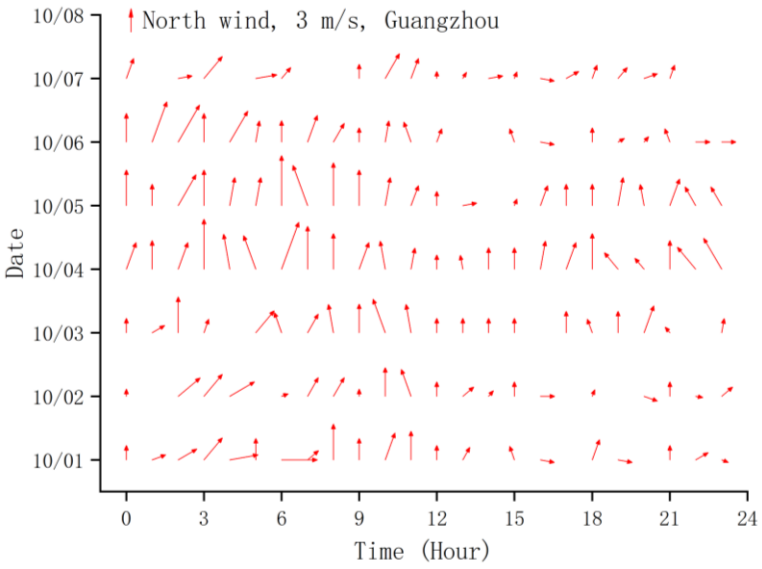

Figure R2-1. The observed wind field in Guangzhou during the CNDH.

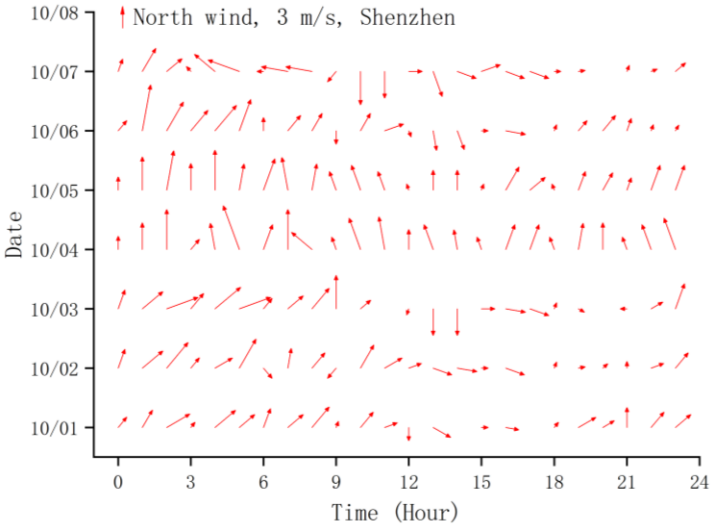

Figure R2-2. The observed wind field in Shenzhen during the CNDH.

2. Line 24. This "303%" overstates the health risk, because the absolute difference is small (0.4 vs 1.6 in Figure 5).

Response: Thanks for the comment. We used the absolute number in the revised manuscript instead of the increasing, which may avoid the 'overestimation' of the health risk. The aggravated health risk in the tourist cities such as Sanya is a crucial message for our study, and we prefer to keep this message in the abstract.

Changes in manuscript: (line 23-24) Moreover, in tourist cities such as Sanya, daily mortality even increases significantly from 0.4 to 1.6.

3. The following terminologies/calculations should be elaborated: O3_VOC, O3_NOx, O3 production rate, and exceeding rate (Figure 1c).

Response: Thanks for the comment. We have elaborated these terminologies in the manuscript and corresponding figures caption.

Changes in manuscript: (line 76-80) Two non-reactive O_3 species: O_3_NO_x and O_3_VOC are added in the CMAQ model to quantify the O_3 attributable to NO_x and VOCs, respectively. In particular, O_3_NO_x stands for the O_3 formation is under NO_x -limited control, and O_3_VOC stands for the O_3 formation is under VOC-limited control. The details of the 3R scheme and the calculation of O_3_NOx and O_3_VOC are described in *Wang et al.* [2019]. (line 157-160, caption of Figure 1) Figure 1. (a) The observed average MDA8 O_3 in PRE-CNDH, CNDH and AFT-CNDH in South, East, West and North China in 2018; (b) The increase rate of observed MDA8 O_3 during CNDH; (c) The exceeding rate of observed MDA8 O_3 in CNDH and October (the exceeding days during the CNDH divided by that during the October, exceeding_CNDH/exceeding_October). (line 181-183, caption of Figure 2) Figure 2. (a) Comparison of observed (circle) and predicted MDA8 O_3; (b) Spatial distribution of O_3_NO_x; (c) Spatial distribution of O_3_VOC in China in PRE-CNDH, CNDH and AFT-CNDH, respectively. Units are ppb. O_3_NO_x and O_3_VOC are the O_3 attributed to NO_x and VOCs, respectively. (caption of Figure S7 in the supplement) The O_3 production rates stand for the total production of O_3 by adding all reactions that O_3 is defined as a product. (line 222-224) The higher O_3 production rates that are calculated by the PA process directly in the CMAQ model (increase rate up to ~150%) are predicted observed mainly in the urban regions (the NCP, YRD, and PRD) in China (Fig. S7).

4. To corroborate the estimated health risks, the estimated daily mortality (non-accidental causes) should be compared to real mortality data, if possible.

Response: Thanks for the comment. The real mortality data is not available although we have tried our best to find this data.

Reference:

Wang, P., Y. Chen, J. Hu, H. Zhang, and Q. Ying (2019), Attribution of Tropospheric Ozone to NOx and VOC Emissions: Considering Ozone Formation in the Transition Regime, *Environmental Science & Technology*, *53*(3), 1404-1412, doi:10.1021/acs.est.8b05981.