Comments responses

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Title: "Aggravated Air Pollution and Health Burden due to Traffic Congestion in Urban China"

Dear Referee #2,

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

Comments: Authors explore the potential impacts of traffic congestion on urban air quality and the corresponding health risks. This is achieved through the development of improved emission inventories by temporal-allocation of traffic congestion data. The authors utilize traffic data to correct for on-road vehicle emission rates, use the corrected emissions data to drive an air quality model, and explore the potential impacts of traffic congestion on air quality using the model generated fields. The explored concepts are interesting and provide an improved approach towards generating comprehensive emission inventories that can be used as input in air quality models, as well as informing air quality policy design and implementation. While the manuscript is clear and well structured, it can be further improved before publication by considering the following suggestions.

Response: Thanks for the recognition of our study. Below is the response to each specific comment.

Specific comments:

1. Please include a brief description on how (techniques/methods) TomTom estimates travel time and CL (e.g., smartphone apps) and the associated uncertainty.

Response: TomTom's technology takes advantage of GPS devices to determine traffic congestion levels in selected cities(Caban, 2021; Tanveer et al., 2020). With the rapid development of technology, GPS tracking technology is widely used in the traffic field to obtain people's travel patterns and real-time traffic conditions. TomTom calculates the baseline travel time by analyzing free-flow travel times of all vehicles on the entire road network – recorded 24/7, 365 days a year. The CL shows the extra time people need to spend during the congestion. The uncertainties from the TomTom may be asscociated with the

sample numbers. The TomTom data now covers 404 cities across 58 countries and most cities are highly developed, which can't represent the traffic congestion level in developing regions.

Changes in manuscript (lines 100-104): The TomTom data used GPS devices to estimate traffic congestion in a total of 404 cities across 58 countries, aiming to show how people were moving on the local and global levels, in real-time and over time. The TomTom congestion level (CL) describes the extra travel time as a percentage compared to the non-congestion situation, which was obtained in 22 major cities in China (Figure S1).

2. Line 104, regarding the statement "…, traffic flows increased with the severity of CL": please note in the text that according to the sigmoid relationship (Eq 1), Q asymptotes to a maximum value as CL increases.

Response: Thanks for your suggestion. The modifications were taken.

Changes in manuscript:

Abstract (lines 104-105): In these 22 cities, traffic flows asymptotes to the maximum value as CL increases due to the sigmoid relationship.

3. Line 110, "In general, the vehicle emissions were proportional to the traffic flow": please specify which emissions were proportional to traffic flow, the ones you looked at (the 2020 period) or the ones considered by Gong et al. (2017)?

Response: Thanks for your comments. The vehicle emissions such as carbon monoxide (CO), volatile organic compounds (VOCs), nitrogen oxide (NO_x), particulate matter ($PM_{2.5}$ and PM_{10}), and sulfur dioxide (SO_2) are all proportional to the traffic flow from TomTom data. The proportional method was from Gong et al. (2017). We have revised the manuscript to clarify this information.

Change in manuscript (lines 111-112): In general, the vehicle emissions were proportional to the traffic flow based on TomTom data as described by Gong et al. (2017), and the temporal coefficient was calculated as the Eq. (2):

4. Section 2.2: what were the model horizontal, vertical and temporal resolutions for CMAQ and WRF simulations. What are the potential impacts of model resolution on your results and how are your chosen resolutions justified for this study?

Response: Thanks for your comments. The horizontal resolutions are 36×36 km^2 and the temporal resolutions are one hour for both CMAQ and WRF models. For the vertical resolutions, a total height of ~30km divided into 18 sigma layers with the first layer height at a height of ~35 m from the surface is

applied in the WRF-CMAQ model system. The resolution plays an important role in the model's performance. If a finer horizontal resolution was used in this study, a better model performance might be expected as well as a relatively more computing time. We selected this resolution with the consideration of both model performance and computing cost. In addition, many previous studies also reported this resolution settings are able to provide robust results for the air quality analysis (Wang et al., 2021; Zhu et al., 2021; Hu et al., 2016).

5.Section 3.4: how about uncertainties in TomTom congestion level data?

Response: The uncertainties in TomTom congestion level data are mainly from the number of samples. Although the TomTom database covers 404 cities across 58 countries, most cities are located in high-developed regions. The congestion level in suburban and rural regions still lack. In our study, we use the TomTom data to adjust the transport emission at the national level, which may overestimate the congestion level in the suburban and rural regions.
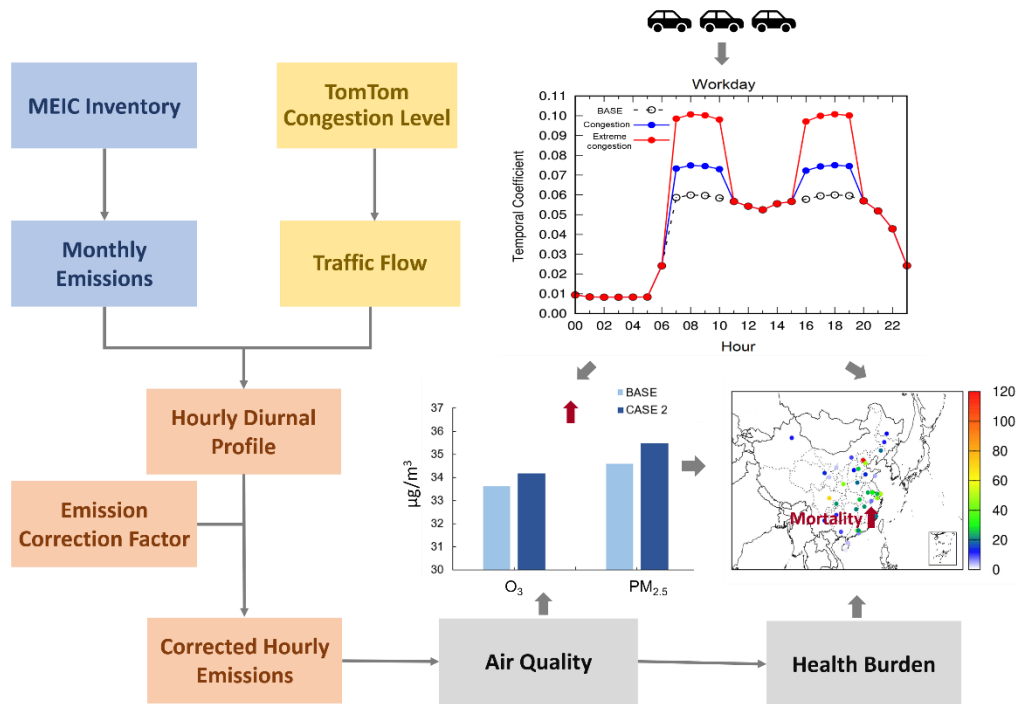
6.Taking vehicle speed into account to correct for estimated emission rates is a step in the right direction and as you have shown has important implications for accurately forecasting urban air quality levels. Considering other relevant processes, it has been shown that Vehicle Induced Turbulence (VIT) can impact pollutant dispersion/transport in the atmosphere and it is advantages to take VIT into account for sub-grid diffusion parameterizations in air quality models (e.g., Makar et al., 2021). Please comment on whether this has been accounted for in your CMAQ simulations - also what implications can VIT have for your results.

Response: Thanks for your suggestion. The VIT process has not been considered in our study due to data limitations. The implementation of the VIT in the air quality model may improve the model performance and more remarkable changes in air quality will be predicted under the congestion condition. We plan to cooperate with the field measurement study to form the localized VIT parameterization in China and couple the VIT process in the future study.

Technical corrections:

1.Graphic abstract: figure sizes and figure font sizes (e.g., title, legends, labels, tick labels) can be increased to improve readability. (a) needs to be removed from the Mortality figure (bottom-right).

Response: Thanks for your suggestion. The modifications were taken.

2.Please add label (with units) to Figure S1b color-bar.

Response: Thanks for your suggestion. The modifications were taken.
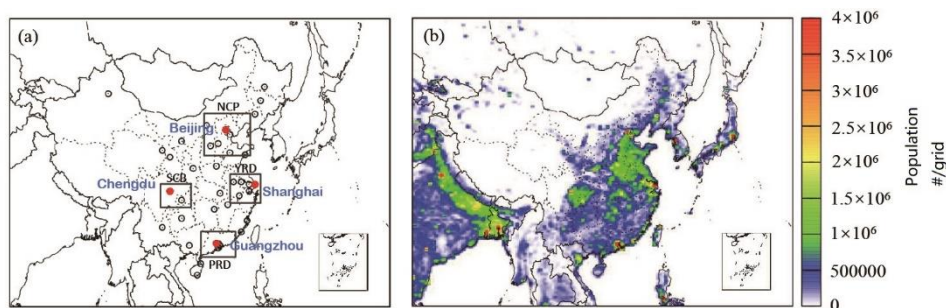
Changes in SI (Figure S1):

Figure S1. (a) is the CMAQ study domain and the key cities in China, and (b) is population data used in this study. For panel (a), red circle: cities in the TomTom data base, red dot: megacities (Beijing, Shanghai, Guangzhou, and Chengdu), black circle: other key cities in China such as the provincial capital.

3.Line 117: revise "… vehicles were more polluted" to "… vehicles were more polluting"

Response: Thanks for your suggestion. The modifications were taken.

Changes in manuscript: (lines 117-119): During off-peak traffic hours, the emission rates were significantly lower than peak hours because vehicles were more polluting under congested conditions due to the frequent low and idle speed (Zhang et al., 2020).

4.Line 199 and 200: consider revising "As a result, the workday rush hours are selected as 07:00-10:00 am and 4:00-7:00 pm, 10:00-11:00 am, and 14:00-19:00 on weekends".

Response: Thanks for your suggestion. We have revised the sentence.

Changes in manuscript (lines 205-207): As a result, rush hours are selected as 07:00-10:00 am, 4:00-7:00 pm, and 10:00-11:00 am, 2:00-7:00 pm for workdays and weekends, respectively.

5.Line 219: consider revising "…, where have higher vehicle numbers and population density".

Response: Thanks for your suggestion. The revision was taken.

Changes in manuscript (lines 223-225): Notable increases in NO_x, VOCs, and CO emissions are found in CASE 2 compared with the BASE case, especially in the areas with higher vehicle numbers and population density, such as the North China Plain (NCP), Yangtze River Delta (YRD), and Sichuan Basin (SCB).

6. Please consider also including BASE-WE on Figure 3 and Figures S9 to S12.

Response: Thanks for the comments. The modifications were taken.
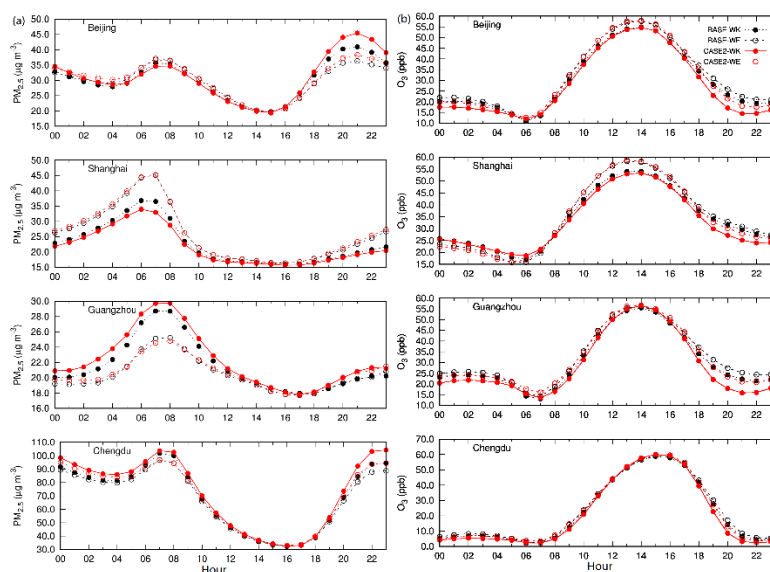
Changes in manuscript(Figure 3 and Figures S9-S12):

Figure 1. The diurnal profile of $PM_{2.5}$ and O_3 concentrations of BASE (without considering congestion) and CASE 2 (considering congestion) in Beijing, Shanghai, Guangzhou, and Chengdu, respectively. WK: workday, and WE: weekend.
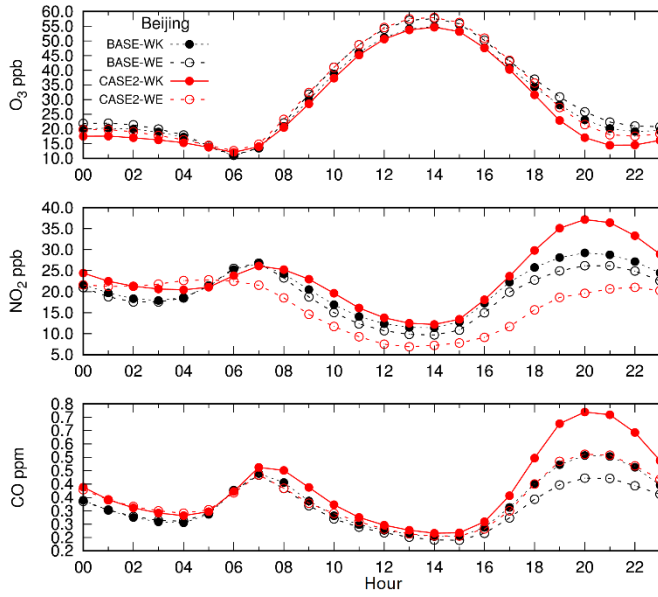
Figure S9. The diurnal O_3, NO_2, and CO concentrations of BASE and CASE 2 in Beijing. WK: workday, and WE: weekend.
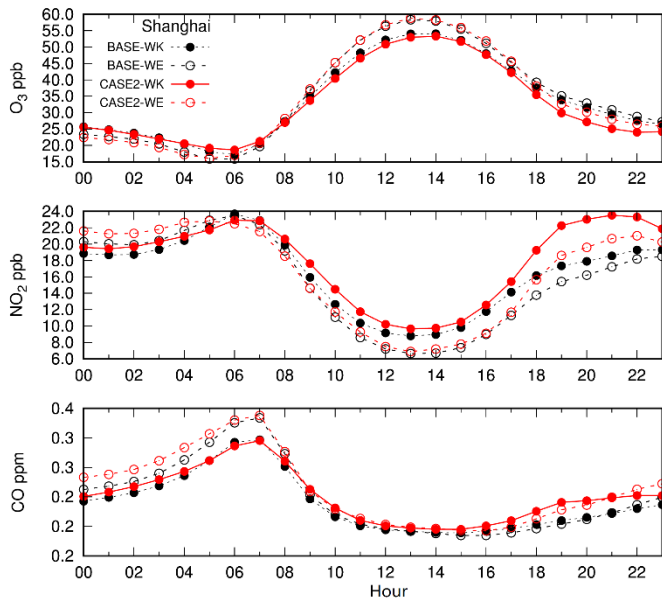

Figure S10. The diurnal O_3, NO_2, and CO concentrations of BASE and CASE 2 in Shanghai. WK: workday, and WE: weekend.
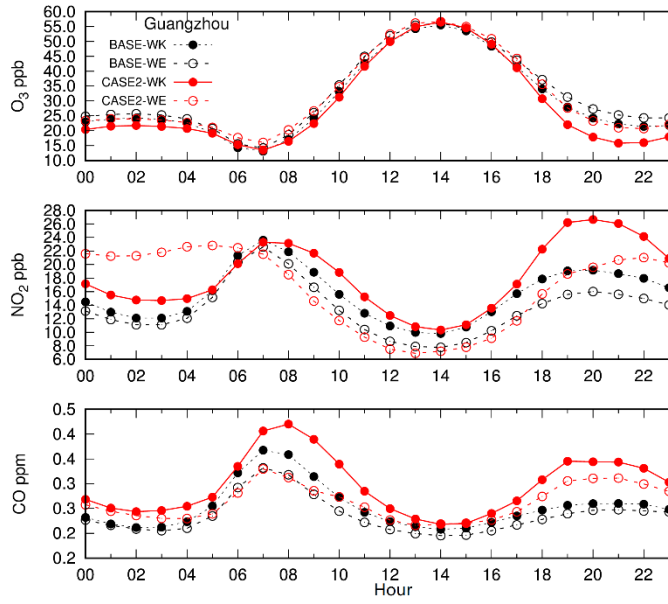
Figure S11. The diurnal O$_3$, NO$_2$, and CO concentrations of BASE and CASE 2 in Guangzhou. WK: workday, and WE: weekend.
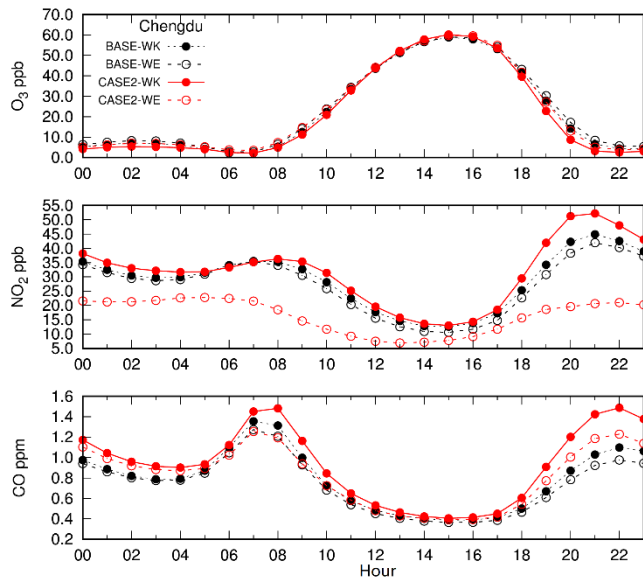

Figure S12. The diurnal O$_3$, NO$_2$, and CO concentrations of BASE and CASE 2 in Chengdu. WK: workday, and WE: weekend.

Reference

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