Dear editor and reviewers,

Thank you for your comments and suggestions. We carefully addressed them one by one as shown below. Hope you find our revisions useful. Thank you again.

Regards,

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1. **Regarding this comment "The choice of 2017 as the year of interest is based on the completeness of data. Nevertheless, how is this year relevant to the epidemiological data that the author plans to investigate further? The applicability of the annual model to current epidemiological studies seems somewhat limited. Given the study's title, could the author shed more light on this concern?" I feel that the authors gave a good response, but edits made were entirely in the discussion at the end of the paper. If "implications for epidemiological research" is really important as the title would suggest, then consider discussing this context in the Introduction. I would also encourage the authors to consider removing "implications for epidemiological research" from the title, since it is not clear to me that this is a major focus of the paper.**

Response: Thanks for the comment. Taking into the reviewer’s comment and your suggestion, we decide to remove the “the implication for epidemiological research”. Nevertheless, in the *Introduction* section, we still mention the benefit to develop an integrated model framework for supporting epidemiological studies (Line 50-54, Line 55-56, Line 63-67).

2. **Regarding this comment "The author refers to the work as an "integrated model framework". However, I can only discern individual LUR models designated for each pollutant. Could the author elaborate on how the integration of this model framework was accomplished?" The authors responded by clarifying that there are PM and GAS modules. But the reviewer's question remains unanswered from what I can tell. In what way is this framework integrated? Are separate LUR models created for each**

pollutant independently? Do measurements of one pollutant in any way influence predictions of another pollutant? It seems that more clarity is important to understand this integrated framework. Also, what are the roles of the two modules and their interactions within the framework?

Response: Thanks for the comment. Our model framework is developed to provide a platform allowing users to run the two modules with multiple air pollutants by inputting one set of input data. We selected the term "integration" instead of "coupling" because the results of one module do not affect the calculation of another module. In the revised manuscript, we clarify the model development of PM and GAS modules and their roles and interactions (Line 79-84).

Line 79-84: *The integrated model framework handles the input datasets required for the PM and GAS modules and develops the LUR models of each air pollutant independently. The LUR models and the corresponding spatial distribution maps within each module can be used to further validate the LUR models and the corresponding spatial distribution maps under another module (Li et al., 2021). For instance, in high-density cities, the spatial distribution of O_3 shows a generally opposite spatial variability compared with traffic-related air pollutants because of the NO_x reaction with O_3. The established LUR models of the PM and GAS modules were used for the assessment of exposure in epidemiological studies.*

3. **Regarding these comments "The models were specifically developed for "high-density cities". Still, it appears that there is a mismatch between the sparse density of monitoring stations and the actual population density. Could the author provide further clarification on this discrepancy?" and "Overall, it appears that the number of data points presents a significant limitation in this study. Would the author consider adopting a spatio-temporal model to incorporate a larger data set with finer temporal resolution?" The authors responded by saying that the monitoring stations are diverse and representative. Please consider strengthening the discussion on the adequacy of monitoring for this purpose in this city and other high-density cities, and on possible alternative methods that could be used depending on the density of monitors.**

Response: It should be noted that the adequacy of monitoring for the purpose of developing a LUR model should not be determined by the number of stations alone. Some more factors should also be considered, such as whether the stations can reflect the characteristics of the air pollutants at their locations and in their surrounding areas, etc. This is the reasons why we highlighted the representation of the stations in our responses before. Furthermore, we have done detailed model evaluations as reported in our manuscript that provided sufficient evidence showing the adequacy of monitoring for our model development. As suggested by the editor, we strengthened the corresponding discussion.

Line 261-263: *High-density cities usually have spare air quality monitoring stations. This discrepancy clearly highlighted the need to develop LUR models for the spatial mapping of air pollution in high-density cities. This work developed an integrated model framework for a high-density city based on the air quality data collected at the sparse monitoring stations.*

Line 265-268: *Similar to other LUR model studies, one limitation of this study is typically the limited number of monitoring stations. It should be noted that the adequacy of monitoring should not be determined by number of stations alone. This study therefore performed detailed evaluations to examine the adequacy.*

Line 272-276: *The detailed evaluation results have proved that our models had promising performance and are capable of reflecting the air quality characteristics of the city. Therefore, our models are considered as sufficient for the scope of this study. Certainty, it is strongly recommended to carry out a further study using different modelling methods (e.g., machine learning) when more data are available with at a finer temporal resolution or collected from a larger number of monitoring stations.*

4. **Line 141: it's still not clear to me what the "pre-defined" direction refers to. Where is it defined?**

Response: The "pre-define" is indeed confusing. We revised the related content to make it clearer (Line141-143, Line 147).

Line 141-143: *The method computed the direction of effect for a predictor variable to reflect the effect of the predictor variable on air pollutant concentration. While the effect of a predictor variable can be positive or negative, the direction of effect for each type of predictor variable was first judged based on the currently known relationship between the predictor variable and the corresponding air pollutant.*
Line 147: *... the direction of effect was consistent with our judgement.*

5. **Line 128: "To include the effect of potential transboundary pollution, the geo-locations of longitude and latitude were also adopted which could reveal a north-south or west-east gradient of air pollutant concentrations (Huang et al., 2017)." I don't think this statement is correct. The longitude and latitude are associated with north-south and east-west variability not captured by the other covariates in the model.**

Response: We have revised the mentioned content as suggested by the reviewer (Line 133-135).

Line 133-135: *The geo-locations (longitude and latitude) were also adopted because they can reveal a north-south or west-east variability gradient of air pollutant concentrations which are not captured by the selected predictor variables in the model (Huang et al., 2017).*

6. **Line 277: "However, as revealed by the present study and previous studies (HKEPD, 2022; Zeng et al., 2022), O3 pollution has become an emerging issue, especially in rural areas of Hong Kong, which cannot be accomplished through the control of vehicular emissions." I don't think this is quite correct either. Vehicular emission control could feasibly reduce NOx emissions, which may produce O3 that is transported to rural areas. In addition, NOx contributes to HONO, which can be transported to rural areas and lead to O3 formation: [Song, M., Zhao, X., Liu, P. et al.**

Atmospheric NOx oxidation as major sources for nitrous acid (HONO). npj Clim Atmos Sci 6, 30 (2023).]

Response: We have revised the mentioned content (Line 289-299).

Line 289-299: *For instance, the Hong Kong government has spent tremendous efforts on the reduction of vehicular emissions over the past two decades, which successfully reduced traffic-related air pollutants like PM2.5 and NO2. However, as revealed by the present study and previous studies (HKEPD, 2022; Zeng et al., 2022), O3 pollution has become an emerging issue, especially in rural areas of Hong Kong. The relationship between the control of vehicular emissions and O3 pollution is complex (Song et al., 2023; Zeng et al., 2022). In Hong Kong, NOx reductions from the control of vehicular emissions may lead to an increase in the levels of oxidants, and then cause a net O3 production. It is suggested that the control of volatile organic compounds should be implemented to better mitigate O3 pollution in HK (Zeng et al., 2022). This highlights the importance to simulate multiple air pollutants together during exposure assessments. In addition, more research should be conducted to understand the complex and varying interaction of emission sources, pollutant sensitivity to precursors, and air quality in a city to formulate more effective and specific air quality management policies.*