Respose to the Comments from Reviewer 2

We would like to thank you for your careful reading, helpful comments, and constructive suggestions, which has significantly improved the presentation of our manuscript. We are grateful to the reviewers for their insightful comments on my paper. We have been able to incorporate changes to reflect most of the suggestions provided by the reviewers. We have highlighted the changes within the manuscript.

Indeed, the uneven distribution of monthly emission factors in the EMEP model could lead to a similar issue in the regional chemical fields downscaled and redistributed to the uEMEP model, resulting in a certain degree of error between the simulation results and observations. Meanwhile, the high-precision industrial emission data used in this study temporarily only considered enterprises above a certain scale in Foshan City, lacking emission data from small and medium-sized industrial enterprises. Incorporating industrial emissions from these smaller enterprises and considering specific urban traffic characteristics could enhance the simulation accuracy of the EMEP and uEMEP models. Optimizing emission inventories is crucial for better reflecting air quality in industrialized and densely populated urban areas. This study explored the localization deployment and simulation performance of the uEMEP model in Foshan City, a region with a high population density, dense industrialization, and a complex road network. While there is still significant room for improvement in the model's performance, its pioneering application in China holds a certain degree of research significance.

Here is a point-by-point response to the reviewers' comments and concerns.

Comments from Reviewer 2

Comment 1：The authors say in several places that uEMEP results bring added values compared to EMEP (l. 325…, 400…, 405...). This is not supported by the figures they give in Appendix B. Regarding Normalized Mean Bias for example, uEMEP performs marginally better than EMEP for L1-L2, much worse for L3-L4 (Table B2). The same is true for PM2.5 (Table B4). Therefore, the authors seem to be discussing what the wanted to find (strong added value with uEMEP) rather than what they actually found (no added value / degradation). This appeare to me as a major flaw in the scientific method.

Response: Thank you for pointing this out. Your observation is valid. Since the uEMEP model is driven by the EMEP model, the pollutant spatial fields input into uEMEP from EMEP have a significant impact on its simulation performance. As you mentioned, Figure 4 demonstrates that while both models exhibit relatively large deviations from the observations, the uEMEP model, with its input of higher-resolution emission inventories, does exhibit slightly better simulation performance compared to the EMEP model.This improved performance can be attributed to the fact that the higher-resolution emission inventories provide a more detailed and accurate representation of the pollutant sources and their spatial distribution in the region. This, in turn, allows the uEMEP model to generate more precise simulations of air quality.However, it is important to note that despite the slight improvement, there is still room for further optimization and refinement of both the EMEP and uEMEP models.

As discussed earlier, the inclusion of emissions from smaller industrial enterprises and the consideration of urban-specific factors, such as road networks and population density, could help improve the accuracy of the models even further.

Comment 2：Tables B2 and B4 show a general and massive underestimation by the simulations in both NO2 and PM2.5. This is not discussed in the article, and questions all the results.

Response: Thank you for pointing this out. The high-precision industrial emission data used in this study only considered enterprises above a certain scale in Foshan City, and lacked data on emissions from small and medium-sized industrial enterprises. This could be one of the reasons for the underestimation of NO_2 and $PM_{2.5}$ simulations.

Comment 3：The tracing methodology in Figure 9 is not explained, and I find the results very questionable. The authors mention that « regional transmission » (meaning not clearly defined) represents up to 99.4 % of the total NO2 quantity for two pollution peaks. How could this possibly happen in a city like Foshan which is presented by the authors as extremely industrialized and with strong trafic ? Here again, the authors seem to lack a critical analysis of their results.

Response: Thank you for pointing this out. The uEMEP model can calculate the concentrations of different emissions to derive the contribution of different emission sectors in local emissions. Our explanation of the source attribution analysis based on the concept of a "moving window" is clear. The number of sub-grids included in the "moving window" determines the relative weight assigned to external transport and local emissions during the attribution process.

In our case, having set the grid size in the "moving window" to 3x3, it is possible that this configuration resulted in a relatively high proportion of the total pollution attributed to regional transport. However, when focusing on the contribution of local sectors, you observed that the transportation sector had the largest share.

This finding is consistent with the common understanding that in urban areas with dense road networks, the transportation sector is a significant contributor to air pollution. The high local contribution from the transportation sector highlights the importance of targeting this sector for pollution reduction measures in Foshan City.

It is also worth noting that the choice of grid size in the "moving window" can affect the attribution results. Larger grid sizes may capture more regional transport, while smaller grid sizes may provide a more localized perspective. Therefore, sensitivity testing with different grid sizes could provide additional insights into the relative contributions of external transport and local emissions.

Comment 4：What I see in their results, with such a massive underestimation of PM2.5 and NO2 is probably either a massive underestimation in emissions (which the authors seem to consider in their conclusions). The point of Gaussing grid modelling with tools such as uEMEP being to better evaluate benefit of a good knowledge of local emissions to improve street-level results, the fact that the emissions seem to be so massively underestimated questions the entire point of the article.

Response: Thank you for pointing this out. We agree with this comment. Absolutely, the underestimation in the emission inventory is indeed a major contributor to the underestimation in the simulation results. As you mentioned, the lack of emission data from small and medium-sized industrial enterprises in the current study likely contributed significantly to this underestimation, especially for pollutants like NO_2 and $PM_{2.5}$. To improve the accuracy of the simulations, it is crucial to optimize the emission inventory by including emissions from all relevant sources, including smaller industrial enterprises. This will help provide a more comprehensive representation of the emissions landscape in the region and potentially lead to more accurate predictions of air quality.In addition, the complexity of the urban environment, including road networks, population density, and industrialization, also plays a significant role in air quality modeling. Therefore, a comprehensive and updated emission inventory that considers all these factors is essential for achieving accurate simulation results.