Re: We thank the reviewers for your careful read and thoughtful comments on our manuscript. We have carefully taken your comments into considerations in preparing our revision, and below marked in blue is our response to your comments point by point, or you can see the revised manuscript for more details. Thanks again for your comments.

Specific:

Reviewer 1: General comments: This study presents a new version of the regional urban road network air quality modelling system IAQMS-street v2.0 to simulate urban background and road network pollution. The manuscript is generally well organised, at this stage the reviewer has a positive attitude towards its publication. However, there are still some points regarding the numerical conditions that should be further explained and modified. The detailed comments of the reviewer are as follows:

Specific comments:

1. Line 163 "The fixed time step for interfacing between NAQPMS and MUNICH was 20 min, i.e., the same as that of the regional model." Is the time step 20 min also for MUNICH? As this study focuses on pollutant diffusion and chemical reaction at the street scale (100 m). The reviewer thinks that 20 min is too long. For example, the previous study on MUNICH with chemical reactions used a time step of 100 s. https://doi.org/10.5194/gmd-15-7371-2022. Please justify that the simulation results based on 20 min can achieve similar simulation accuracy with a smaller time step (e.g. 5 min). In addition, a sensitivity test should also be carried out on the time step for the interface between NAQPMS and MUNICH (e.g. 5 min).

Re: Thank you for reading this manuscript carefully and asking questions. Your comments are critical to improve the content of the manuscript. In MUNICH, the time step was setting as 1200s (20min) to corresponding with the time step in NAQPMS. In previous study, the performance of MUNICH with different time steps (100s and 600s) on street and background has been evaluated in Paris (Figure R1 and R2). In Figure R1, the results showed that the street concentrations of NO_2 and NO are numerically stable and independent of the choice of the time step in MUNICH with nonstationary approaches, and the nonstationary approaches decreased the influence on background concentration with different time step in Figure R2 (Lugon et al., 2020).

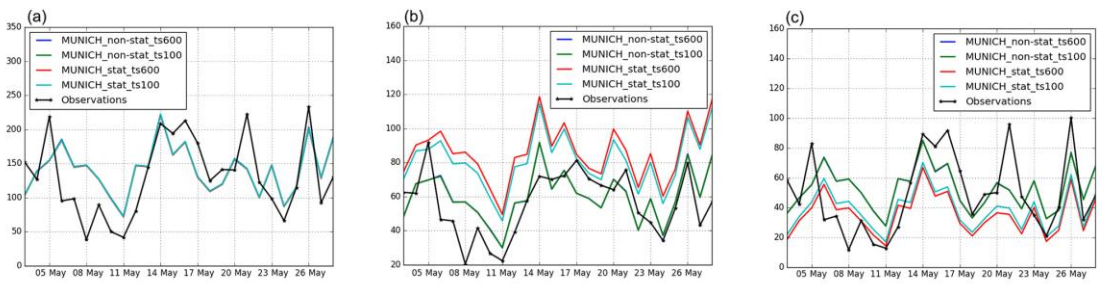

Fig R1. Daily average concentration of NO_x(a), NO_2(b), and NO(c) concentration ($\mu g/m^3$) simulated by MUNICH in Paris with different time step (600s and 100s) using the stationary and nonstationary approaches (Lugon et al., 2020).

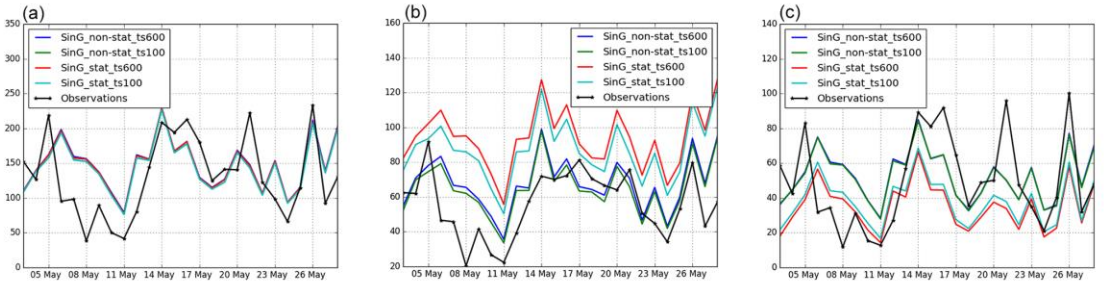

Fig R2. Daily average concentration of NOx(a), NO_2(b), and NO(c) concentration (μg/m^3) simulated by SinG (a multi-scale model that couples MUNICH with the regional model Polair3D) in Paris with different time step (600s and 100s) using the stationary and nonstationary approaches (Lugon et al., 2020).

In this study, the nonstationary approaches have been used in MUNICH. Based on reviewer's comments, a sensitivity test has been carried out on the time step (Delta time=20min and Delta time=5min) for the interface between NAQPMS and MUNICH to quantified the influence of time step on simulation results. As shown in Fig R3 and R4, the simulation of NO_x and O_3 with time step 20min and 5min were close to observations at monitoring sites. The hourly simulation results at monitoring sites were compared in Fig R5. The FAC2 between simulation results of O_3, NO, and NO_2 by time step 20min and 5min reached 0.99, 0.97 and 1.0 and The NMB of O_3, NO, and NO_2 is 0.03, 0.11, and 0.03. Overall, the simulation results based on 20 min can achieve similar simulation accuracy with a smaller time step (5 min). The sensitive analysis with different time step (20min and 5min) were added in the revised manuscript, please see the revised manuscript from line 370 to line 377 for more details.

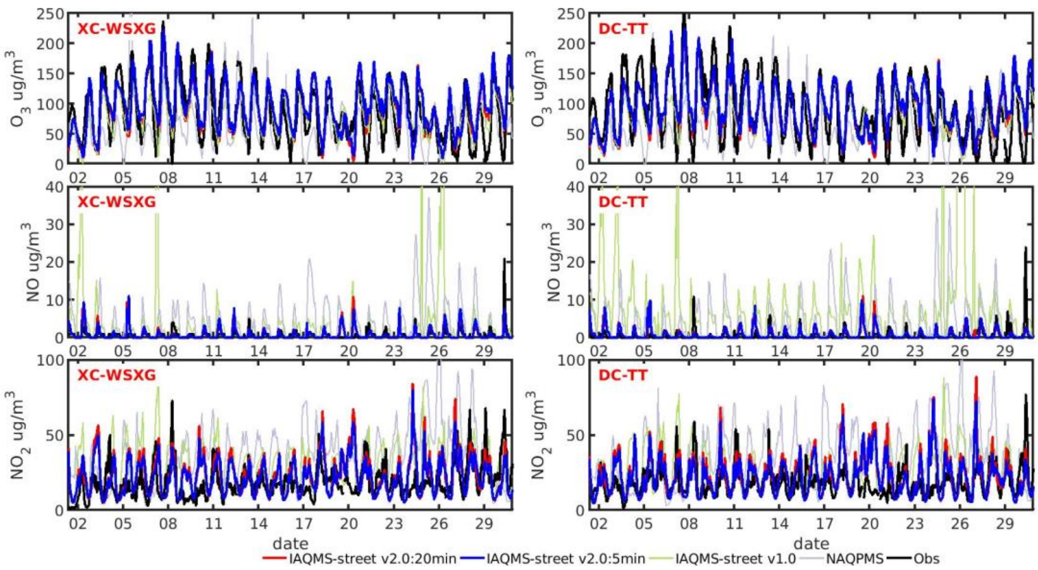

Fig R3. Hourly variation of O_3, NO, and NO_2 concentrations (unit: μg/m3) during August 2021 at the Dongcheng-Tiantan (DC-TT) station and Xicheng-Wanshouxigong (XC-WSXG) station. Red lines indicate values simulated by IAQMS-street v2.0 with 20 min time step; blue lines indicate values simulated by IAQMS-street v2.0 with 5min time step; green lines indicate values simulated by the IAQMS-street v1.0; blue lines indicate values simulated by NAQPMS; and black lines indicate observations.

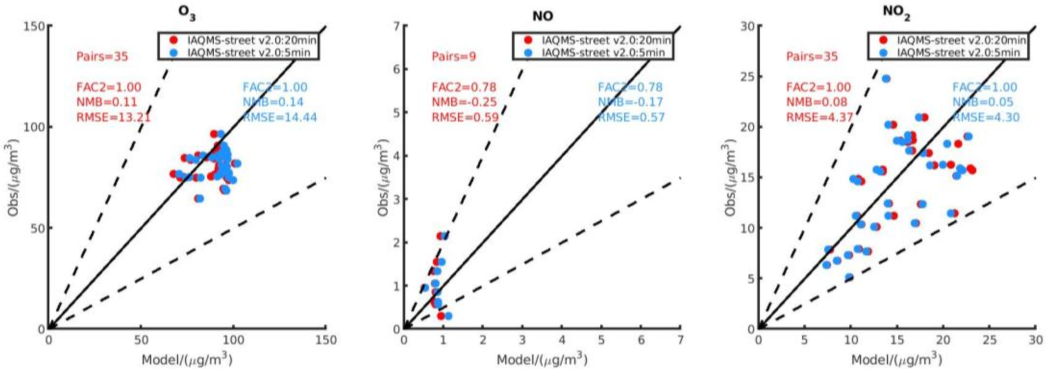

Fig R4. Observed and simulated average O_3, NO, and NO_2 concentrations during August 2021 from IAQMS-street v 2.0 with different time step (20 min: red points; 5min: blue points) at all pollutant monitoring stations in Beijing.

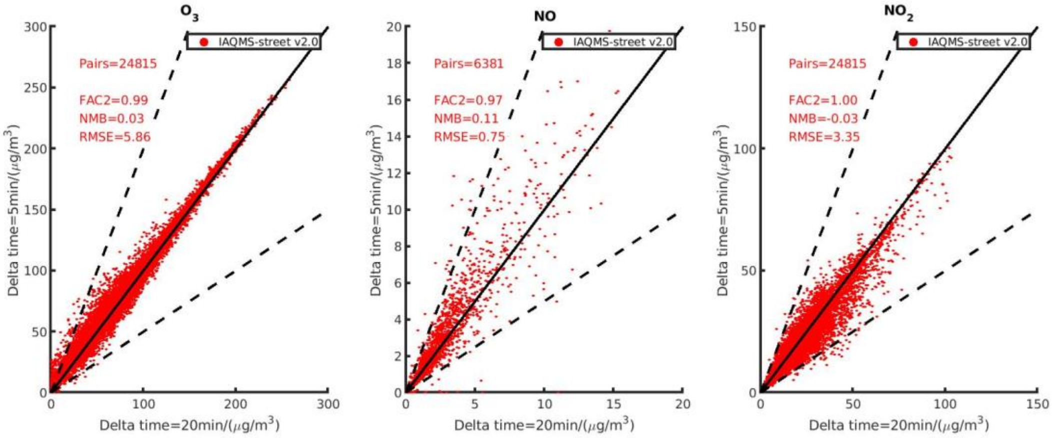

Fig R5. The comparison of simulated hourly O_3, NO, and NO_2 concentrations during August 2021 from IAQMS-street v 2.0 with different time step (20 min and 5 min) at all pollutant monitoring stations in Beijing.

2. Figure 1. How high is the bottom layer in this study? Please provide a reasonable explanation that the simulation results are not dependent on the height of the bottom layer.

Re: In this study, the height of the bottom layer in the regional model is 48.32m over the Beijing area, and the average building height in Beijing used in this study is 10.8m. As shown in Fig R6, more than 90% of buildings in Beijing have a height below 20m, and less than 4% of buildings exceeding 50m in height, which basic meets the requirement that the height of the street model need lower than the bottom height of the regional model in two-way coupled models (Lugon et al., 2020). Based on reviewer's comments, the information of building heights and the bottom layer height of regional model in Beijing were added in the revised manuscript. please see the revised manuscript from line 174 to line 177 for more details.

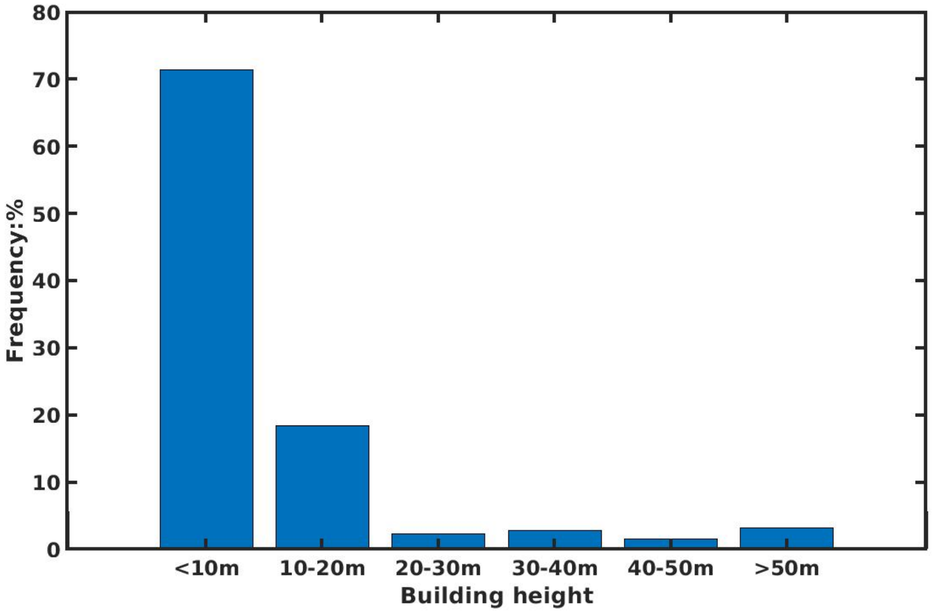

Fig R6. The frequency distribution of building height in Beijing urban area.

3. Figure 7. Why is the number of NO observations less than NO2 and O3? Also, it seems that only the daily averaged data are shown. The hourly averaged data should be shown as the prediction accuracy of the peak concentration is important.

Re: In Chinese National Ambient Air Quality Standards, O_3, $PM_{2.5}$, PM_{10}, CO, SO_2, and NO_2 are listed as six conventional pollutants for monitoring, and NO is not the main monitoring object, so the NO is not observed at all national monitoring sites, which caused the NO observations less than NO_2 and O_3, and the NO observation values are all integer digits in this study. Based on review's comment, the hourly averaged data is added in the revised manuscript (as shown in Fig R7), please see the revised manuscript from line 272 to line 273 and appendix figure (Fig. S1) for more details.

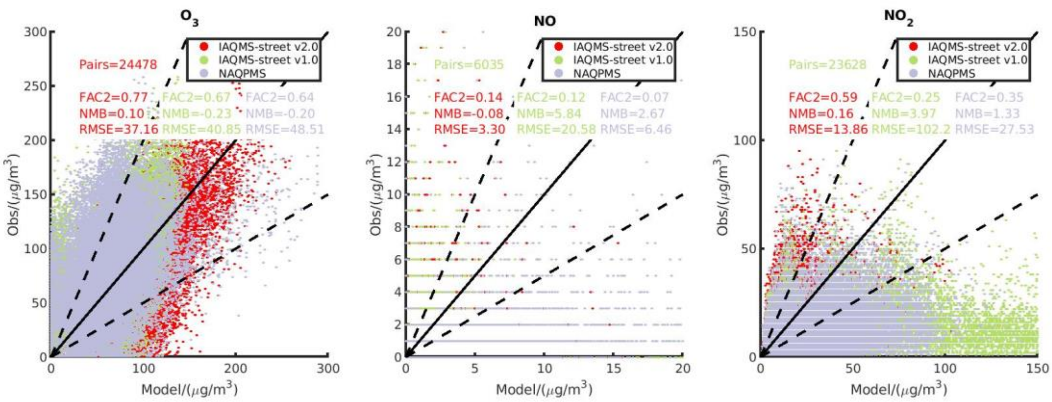

Fig R7. Observed and simulated hourly O_3, NO, and NO_2 concentrations during August 2021 from different models (IAQMS-street v2.0: red points; IAQMS-street v1.0: green points; NAQPMS: blue points) at all pollutant monitoring stations in Beijing.

Technical Corrections

4. IAQMS-street v2.0 could use more CPU time than IAQMS-street v1.0. It is helpful for the potential user of IAQMS-street v2.0 to know the detailed CPU time in this study for different scenarios.

Re: Based on review's comment, the calculation time of IAQMS-street v2.0 and IAQMS-street v1.0 are compared now. In this study, the NAQPMS used 4 nodes and 24 ppn (Processor Per Node) when MUNICH used 1 node and 28 ppn. During the study period, the calculation time is 121.6 h in IAQMS-street v2.0 and 96.2 h in IAQMS-street v1.0, and the calculation time increased to 212.8 h in IAQMS-street v2.0 with smaller time step (5 min). The detail description of calculation time for different scenarios has been added in the revised manuscript. Please see the manuscript from line 378 to line381 for more details.

Reference:

Lugon, L., Sartelet, K., Kim, Y., Vigneron, J., and Chretien, O.: Nonstationary modeling of NO2, NO and NOx in Paris using the Street-in-Grid model: coupling local and regional scales with a two-way dynamic approach, Atmos. Chem. Phys., 20, 7717-7740, 10.5194/acp-20-7717-2020, 2020.

Reviewer 2: In this manuscript, the authors designed a two-way coupled regional-urban–street network air quality model system, and applied and evaluated it in a megacity, Beijing, China. The topic is of great interesting to recognize the complex interactions of air pollutants between larger different scales in spatial dimension inducing by emissions, mass transform andchemisty among the scales. The manuscripts is generally well organized and the analysis is mostly sound. But some details need modify and some ambiguous presentation need clarify. I recommend a minor revision and my comments listed below.

Specific comments:

1. The title should include air quality, indicating you designed a two-way coupled air quality model system.

Re: Thank you for your comments. We appreciate the reviewer's positive evaluation of our work. Based on reviewer's comments, the title has been revised to: "IAQMS-street v2.0: a two-way coupled regional-urban–street-network air quality model system for Beijing, China". Please see the manuscript for more details.

2. In line 11 of the abstract, "gap" could be better replaced by "different" or other word implicating the large different between the concentration in reginal and street scales.

Re: The sentence has been revised to: "the concentrations of pollutants, such as ozone (O_3) and its precursors, have a large difference with the regional averages and their distributions cannot be captured accurately by traditional single-scale air-quality models". Please see the manuscript in line 11 for more details.

3. In line 27 and in the context, cannot say “O3 emissions”.

Re: The sentence has been revised to: “The relative contributions of local traffic emissions to NO_2, NO, and O_3 concentrations were 53.41, 57.45, and 8.49%, respectively”. Please see the manuscript from line 28 to line 29 for more details.

4. In line 121, dc-->dC;

Re: The “dc” has been revised to “dC”, please see the manuscript in line 121 for more details.

5. In line 135, definition γ as mass transfer efficiency may better than mass flux.

Re: The sentence has been revised to: “γ is transfer efficiency between street and background concentration”. Please see the manuscript in line 135 for more details.

6. In line 150, “ in Eq. (3),” could be in Eq. (4)?

Re: The “Eq. (3)” has been revised to “Eq. (4)” in line 150. Please see the manuscript in line 150 for more details.

7. In figure 3b, I found a truck, but the "truck up" and "truck down" were both zero. Were the statistics (in red) right?

Re: In the object detection system, the identified vehicles were counted when they drives across the yellow line (as show in Fig 3b). In Fig 3b, the truck was not cross the yellow line so the “truck up” is keep to zero. Based on reviewer’s comment, the Fig 3b is replaced to which truck has been counted (Fig R8). Please see the revised manuscript for more details.

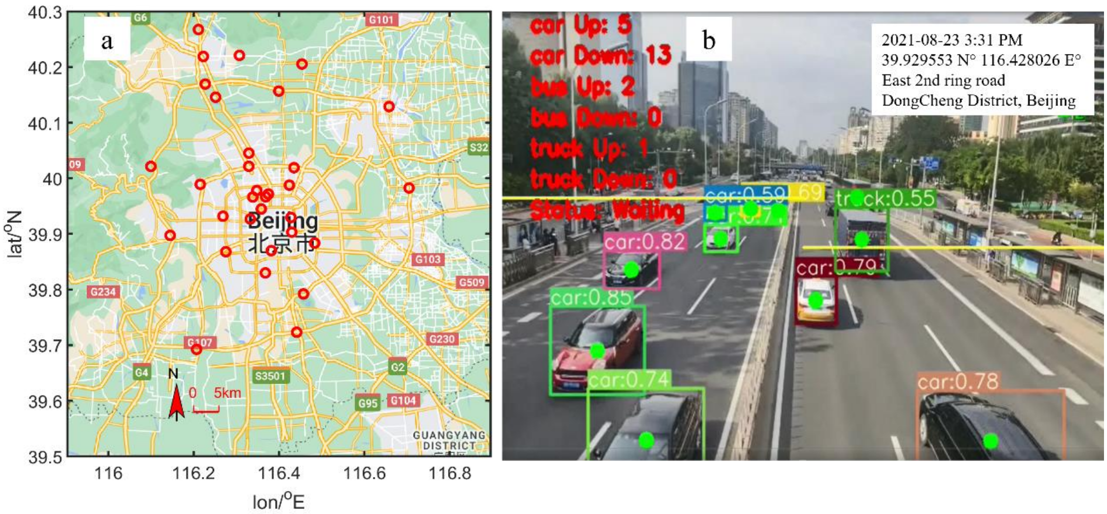

Fig R8. (a) Locations of observation sites on different roads for vehicle information (Imagery © 2022 Google, map data © 2022 Google). (b) Detection results of vehicles on road by the YOLO system.

8. In figure 7, we can find the simulated NO and NO2 in regional (NAQPMS) higher than that in network simulations. So，what's the means of the presentation in abstract "the concentration of NOx at street scale is higher than that at the regional scale,"?

Re: In this study, the NO_x concentration simulated by regional model NAQPMS and coupled model IAQMS-street were compared with observation data at regional scale (Fig 7), the results showed that the NO_x concentration simulated by NAQPMS was overestimate. As mentioned in the abstract, "the concentration of NO_x at street scale is higher than that at the regional scale" is try to compared NO_x concentration in street-scale and regional-scale in the coupled model (the concentration of pollutants in street and in background). Based on reviewer's comment, the sentence has been revised to: "In the coupled model, the concentration of NO_x at street scale is higher than that at the regional scale". Please see the manuscript from line 22 to line 23 for more details.

Date of this revision：

28 Jun 2023