Response to Referee:

Thanks for the replies from the first and corresponding to author Wu. Unfortunately, the following question in the last-round review has not been fully and carefully answered.

The last round of concern is: "I am a little bit concerned about the benefits/advantages when developing this new proposed InMAP-China model. Firstly, the important part of the InMAP-China model is the InMAP model (a reduced-complexity model producing the pollutant concentration), which is under-estimating the $PM_{2.5}$ by 8.1 μg/m³ (Line 239-242). This reduced-complexity model also has difficulties in capturing the SOA (Line 335-336). The simulated concentrations will directly affect the accuracy of health calculations. On the other hand, computing power running chemical transport models is not an issue nowadays. Running it on a coarse resolution such as 36 km is remarkably faster. The running time of a CMAQ model at a resolution of 36 km is around half an hour for one-day output (varies depending on different machine cores). Running the InMAP-China model still needs the CMAQ model outputs for providing extracted parameters. So why not directly using the CMAQ model (in 36 km resolution) to produce the concentration maps for calculating the health?"

The first author's reply: "The loss of accuracy is unavoidable and may need to be further improved in the future study." cannot be accepted. It is reasonable and doable to have more accurate results with even longer running time as pursuing science. More clarification or work (suggested in the last paragraph) must be provided to illustrate the significance of this manuscript and its contribution to the model community.

The first author's reply: "The advantage of InMAP-China is time-efficient when it is used to quantify the contributions of multiple fine emission sources". I don't see the time-efficient since you are making a 36 km resolution and still need to run the CMAQ model to extract the required parameters. Moreover, extensive scenario studies of 36 km resolution are too coarse (for example, urban and rural regions are different), introducing higher uncertainties. Running only a few carefully selected representative scenarios is not expensive using computers nowadays, even with year-long simulations. It is also reasonable and doable to have more accurate results with even longer running time pursuing science. Again, in conclusion, the current implemented reduced-complexity model with 36 km resolution cannot convince the audience that it has the advantage of being time-efficient in conducting air quality predictions.

Due to the authors admit higher resolution is more important for health calculation and the fact that coarse-resolution (36 km) modeling runs are not so time-efficient comparing with traditional chemical transport modeling, one more comparison (InMAP-China and CMAQ5.2) with nested domains (4 km) only focusing on a regional area (Jing-Jing-Ji, or YRD or PRD) need to be further provided as a demo covering four typical months of Year 2017. This should be doable since Tessum (2017) has done the coupling of InMAP with WRF-Chem under the higher-resolution (27km, 9km, 3km, 1km setting) modeling for the US. This set of comparisons will surely convince the audience of the effectiveness and the significance of the InMAP-China and the contribution of this manuscript.

Tessum, C. W., Hill, J. D., & Marshall, J. D. (2017). InMAP: A model for air pollution interventions. PloS one, 12(4), e0176131.

Response:

Thanks for the valuable comments to improve our manuscript.

We take further efforts to answer the questions in your comments. A simulation of 4 km spatial resolution in the BTH region is conducted both using the InMAP-China and WRF-CMAQ-nested. Here, we first conduct a nested simulation using WRF-CMAQ at 4 km spatial resolution in the BTH region and then generate the chemical, meteorological parameters using the preprocessor module established in our study and prepare air pollutants emission file at 4 km resolution for the simplified simulation of InMAP-China.

In our manuscript, we add additional descriptions for the higher resolution simulation in the BTH region in the method part, in Section 2.1.1, Section 2.1.3 (about the model and data for 4km simulation), and Section 2.2.1 and Section 2.2.2 (about the evaluation), can be seen in the revised manuscript. Then we add the result analysis of the simulation with 4km resolution in the BTH region in Section 3.3, here, three new figures including Figure 10, Figure 11, and Figure 12 are inserted. The details of the analysis in Section 3.3 are shown as follows:

"We also conducted a simulation with higher spatial resolution of 4 km in the BTH region by using InMAP-China model and make a comparison with the WRF-CMAQ nested simulations at the same area in the BTH region. Figure 10 and Figure 11 show

the performance evaluation of total $PM_{2.5}$ concentration and the composition in the InMAP_BTH scenario. Compared with the observed annual averaged $PM_{2.5}$ concentrations, the total $PM_{2.5}$ concentrations are moderately overpredicted by InMAP_BTH with an NMB of 41.3% and an R of 0.5. Further compared with the nested CMAQ predictions, the total $PM_{2.5}$ concentrations are also over-predicted by InMAP-China model. The predictions of $PM_{2.5}$ compositions in the InMAP_BTH scenario are partially satisfactory, except for SO_4^{2-}, with NMBs for SO_4^{2-}, NO_3^-, NH_4^+, and primary $PM_{2.5}$ equal to 178%, 36%, 33%, and 27%, respectively. Figure 12 further shows the comparison of the spatial distribution of $PM_{2.5}$ compositions in the BTH region. The overall spatial distribution pattern of $PM_{2.5}$ compositions is similarly modeled by two models, however, an obvious difference can be observed across the mountain area in the BTH region, for instance, the over-predictions of $PM_{2.5}$ compositions, especially, SO_4^{2-} and NO_3^- observed near the Taihang mountain area."

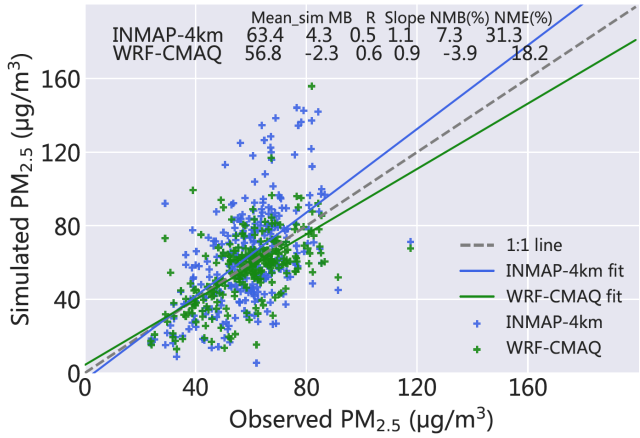

Figure 10 Scatter plot comparing the $PM_{2.5}$ concentration modeled in the BTH region with 4 km spatial resolution by the InMAP-China and WRF-CMAQ. The value of statistical metrics is labeled in the panel.

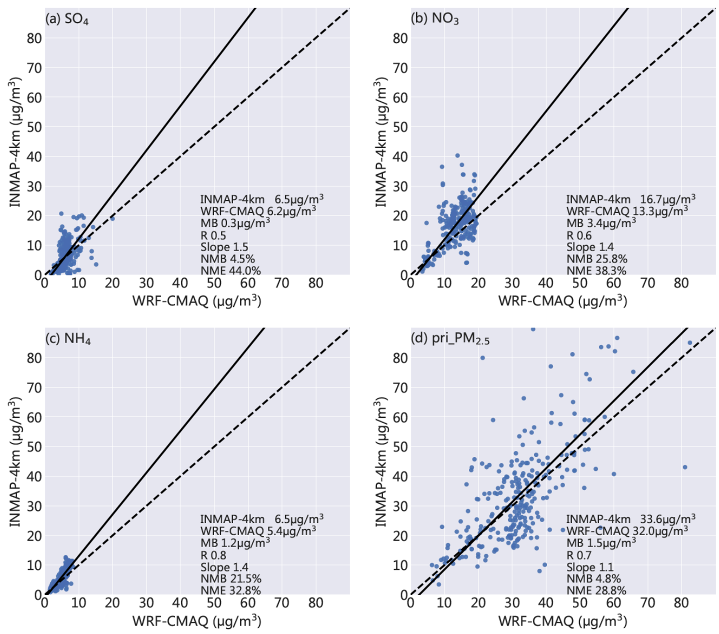

Figure 11 Scatter plot comparing the $PM_{2.5}$ composition concentration modeled at BTH region with 4km spatial resolution by the InMAP-China and WRF-CMAQ. Panels (a), (b), (c) and (d) display the sulfate, nitrate, ammonium, and primary $PM_{2.5}$, respectively. The statistical metrics are labeled in the lower right corner of each panel.

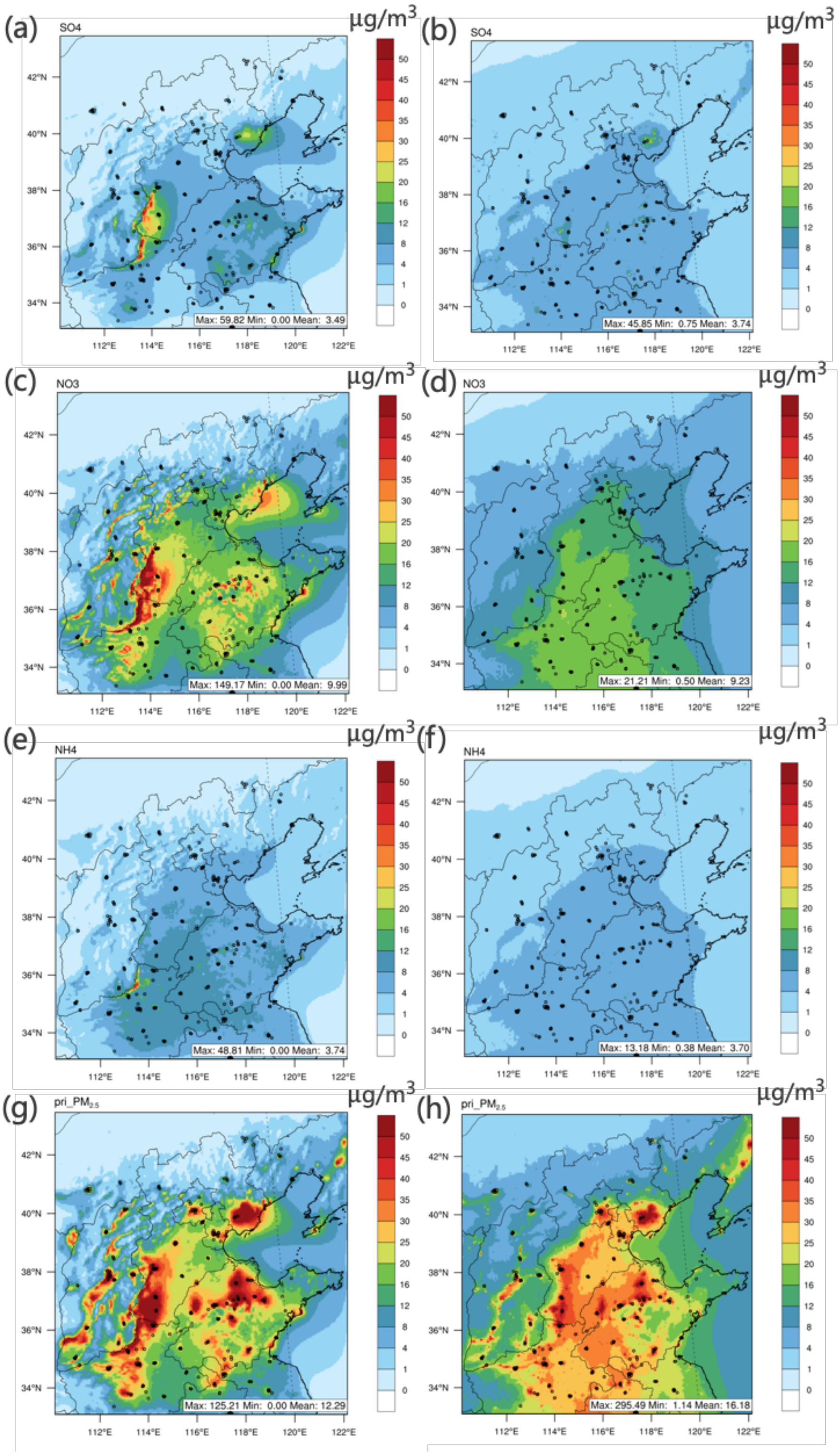

Figure 12 The spatial pattern of $PM_{2.5}$ compositions simulated in the BTH region with 4km spatial resolution by the InMAP-China and WRF-CMAQ. Panels (a), (c), (e), and (g) present the sulfate, nitrate, ammonium, and primary $PM_{2.5}$, respectively, simulated by InMAP-China. Panels (b), (d), (f), and (h) present the corresponding results simulated by WRF-CMAQ.

Besides, we provided the clarification in Section 4 to illustrate the significance of this manuscript and its contribution to the model community, the contents is shown as follows:

"The InMAP-China aims at providing a simplified modeling tool to rapidly predict the $PM_{2.5}$ concentrations due to emission change as well as health impact of emission sources in China. After the model is established, the total consumed time for a new simulation under the atmosphere condition in 2017 across the mainland of China using InMAP-China is merely an hour with a single CPU of 24 nodes. Therefore, it is time-efficient when conduct new simulations of $PM_{2.5}$ concentrations in China. Notably, the running of WRF-CMAQ simulations is merely necessary in our developing stage of InMAP-China. For the application of InMAP-China, we recommend users to select InMAP-China as a prior tool with extensive simulation demands, for instance, to quantify the $PM_{2.5}$ concentrations due to hundreds of pollution emitters or to rapidly estimate the $PM_{2.5}$ concentrations caused by dozens of control policies, separately. Besides, the variable grid can also be set in InMAP-China to allow spatial resolution even at 1km or higher in certain urban area." in the first pargraph and "The global version of reduced-complexity air quality model (Global-InMAP) is also been developed and preprint recently (Thakrar et al., 2021), our results of InMAP-China can provide more accurate result in the mainland of China . " in the last paragraph.

Reference: Thakrar S, Tessum C, Apte J, Balasubramanian S, Millet DB, Pandis S, et al. Global, High-Resolution, Reduced-Complexity Air Quality Modeling Using InMAP (Intervention Model for Air Pollution). ChemRxiv. Cambridge: Cambridge Open Engage; 2021; This content is a preprint and has not been peer-reviewed.