**Responses to the Editor and Reviewers**

We would like to thank editor and the two reviewers for giving constructive suggestions, which are very helpful to improve the quality of the manuscript. All the authors have read the revised manuscript and agreed with submission in its revised form. The referee's *comments* are in black color, our responses are in blue color, and our corresponding revisions in the manuscript are in red color.

**Response to the Reviewer #1**

**General comments:**

*The manuscript was well revised based on the comments and suggestions from the reviewers. It can be accepted with minor revision as follows.*

*As I mentioned previously, the year for the emission inventory and the year for the model were different with eight years difference. In my opinion, the emission inventory should be one of the major uncertainties for the model. Therefore, the problem should be well addressed for the study, especially for the limitations of the model.*

Response: We really appreciate your great efforts and positive evaluation of the manuscript. To address uncertainties in the emission inventory, we added subsection 5.4 to the Discussion section to discuss emission source uncertainties. We analyzed uncertainties of emission sources from two perspectives: different sources' emissions and emissions from different

time periods. We chose Hemispheric Transport of Air Pollution version 3 (HTAPv3) for comparison. We find that HTAPv3 and MIX-Asia exhibit comparable spatial distribution but diverge in degree. Particularly, during March of 2010, HTAPv3's $SO_2$ emissions in northern India exceed MIX-Asia's emissions, whereas the BC and OC emissions in the same region are less than those of MIX-Asia. In general, the variance in emissions of BC, OC, and $SO_2$ from the HTAPv3 inventory when compared to the MIX-Asia inventory in the simulated domain are 28%, 42%, and 20%. We compared aerosol emissions from March 2010 and 2018 using HTAPv3, and found that the differences in BC and OC emissions between the two time periods were small. However, $SO_2$ emissions increased in northern South Asia after 8 years. Our analysis also revealed that the disparities in emission inventory were greater than those between different years of the same inventory. It is worth noting that, if MIX-Asia had been updated, its impact on the results of the two FR experiments would have been limited. Further research will be needed to reduce the uncertainty caused by the considerable differences between the emission inventories.

Changes in Manuscript:

Line 472-489:

5.4 The uncertainty of emissions

The emission inventory serves as crucial input data for the WRF-Chem model. However, it is important to note that the anthropogenic emission inventory in MIX-Asia has not been updated since 2010. Anthropogenic aerosols, including BC, OC, and $SO_2$ emissions, are primarily identified from the emission inventories. To compare differences between emission inventories, we select Hemispheric Transport of Air Pollution version 3 (HTAPv3), which spans from 2000 to 2018 (Crippa et al., 2023). A similar spatial emission distribution is visible when comparing MIX-Asia and HTAPv3 emission inventories (Fig. S1). Specifically, in March 2010, the $SO_2$ emissions in the northern India from HTAPv3 are stronger than those from MIX-Asia. Overall, the emissions differences of BC, OC, and $SO_2$ from the HTAPv3 inventory relative to the MIX-Asia inventory in the simulated domain are 28%, 42%, and 20%. Adopting HTAPv3 emissions results in a greater simulation positive bias than MIX-Asia due to high SO2 emissions, particularly in eastern SA.

Additionally, we analyze the differences in aerosol emissions between March 2010 and March 2018 in the HTAPv3 inventory (Fig. S2). In comparison to 2010, there is less variation in BC and OC in northern SA in March 2018. By contrast, there is a significant increase in $SO_2$ emissions in northeastern SA and a decrease in the western TP. Overall, emission inventory disparities outweigh those between different years of the same inventory. We infer that if MIX-Asia updated, its projected

impact on improving the results of the two FR experiments is limited. Further research will be needed to reduce the uncertainty caused by the considerable differences between the emission inventories.

Reference:

Crippa, M., Guizzardi, D., Butler, T., Keating, T., Wu, R., Kaminski, J., Kuenen, J., Kurokawa, J., Chatani, S., Morikawa, T., Pouliot, G., Racine, J., Moran, M. D., Klimont, Z., Manseau, P. M., Mashayekhi, R., Henderson, B. H., Smith, S. J., Suchyta, H., Muntean, M., Solazzo, E., Banja, M., Schaaf, E., Pagani, F., Woo, J.-H., Kim, J., Monforti-Ferrario, F., Pisoni, E., Zhang, J., Niemi, D., Sassi, M., Ansari, T., and Foley, K.: The HTAP_v3 emission mosaic: merging regional and globalmonthly emissions (2000-2018) to support air quality modelling and policies, Earth System Science Data, 15, 2667-2694, 10.5194/essd-15-2667-2023, 2023.

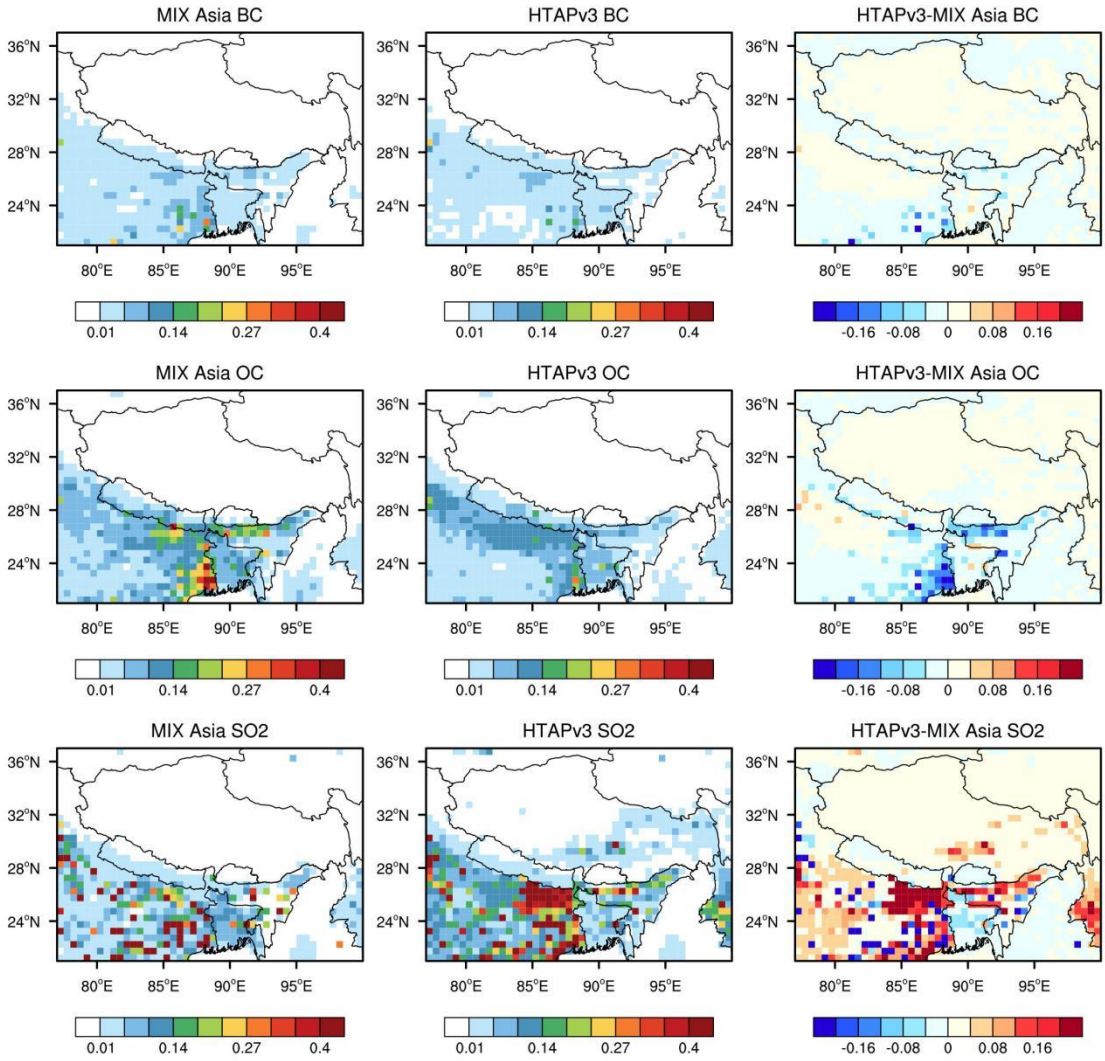


Figure S1. Comparison of emissions of BC, OC, and $SO_2$ (unit: g $m^{-2}$ $month^{-1}$) in the MIX Asian and HTAPv3 emission inventories for March 2010. HTAPv3: Hemispheric Transport of Air Pollution version 3.

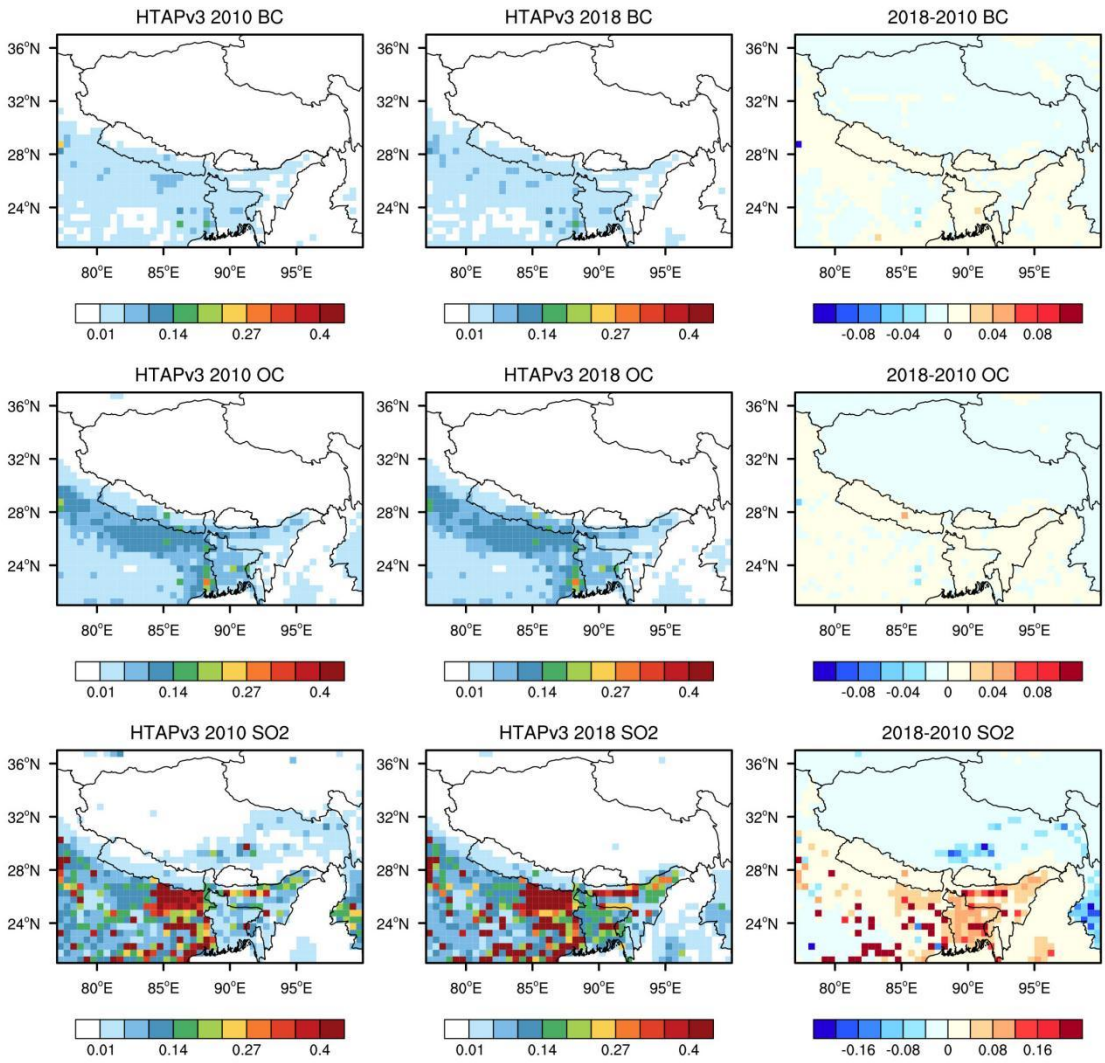


Figure S2. Comparison of emissions of BC, OC, and $SO_2$ (unit: g $m^{-2}$ $month^{-1}$) in the HTAPv3 emission inventories for March 2010 and March 2018.

**Response to the Reviewer #2**

**General comments:**

*The authors have addressed all of my concerns, and I recommend acceptance of the revised paper for publication.*

Response: We really appreciate your great efforts and positive evaluation of the manuscript.