Manuscript # acp-2021-328

Responses to Referee #2

The authors investigated aerosol transport pathways in China during COVID-19. They established the source-receptor relationships among various regions of China using the CAM5 model with the capability of aerosol source tagging. The model system was developed by the same group of this paper and was evaluated in their previous studies. This work suggests that local emissions contribute largely to the severe aerosol pollution in North China Plain and Eastern China during COVID along with moderate impacts from unfavorable meteorological conditions. Overall, this paper reads well and provides interesting results, which could benefit the design of air pollution regulation strategies in China. I have two major concerns about the manuscript in its current form, which need to be resolved before it can be accepted for publication.

We thank the editor for all the insightful comments. Below, please see our point-by-point response (in blue) to the specific comments and suggestions and the changes that have been made to the manuscript, in effort to take into account all the comments raised here.

The first problem is that the CAM5 model used in this work cannot simulate nitrate and ammonium aerosols, while these compositions account for a large proportion of aerosols over China currently. Please provide detailed explanations and discussions on how this model deficiency could impact the main conclusions of this work.

Response:

Thanks for the suggestion. We have now added the following sentences in the discussion section: "In majority of the climate models, the simulation of nitrate and ammonium aerosols are not included in the aerosol schemes, partly due to the complexity of calculation efficiency. For example, in many of the CMIP6 models, only two of them provide nitrate and ammonium mass mixing ratios. Many previous studies have evaluated the global climate models in reproducing aerosol concentrations (e.g., Fan et al., 2018; Shindell et al., 2013; Yang et al., 2017a, b). In general, the models can well simulate aerosols in North America and Europe but significantly underestimates aerosols in East Asia by about −36 to −58 % compared with observations. It can lead to an underestimation of aerosols contributed by Chinese local emissions in magnitudes, but might not change the main conclusions of this study."

The second problem is that the focus of this work is the aerosol source attribution during COVID. However, the authors did not discuss much the special findings in this special period. Compared to previous literature, are there any novel results and conclusions of the contributions from local/nonlocal sources to aerosol pollutions during this period with low emission levels? And what's the implication for air pollution control policies in China, especially considering that the anthropogenic emissions will be rapidly reduced in the future?

Response:

Thanks for the suggestion. We have now included such context in the discussion section as follows: "Source tagging and apportionment is an effective way to establish aerosol source-receptor relationships, which is conducive to both scientific research and emission control strategies (Yu et al., 2012). Previous studies only focused on regional transport of aerosols, very few studies have explored the aerosol transport pathways and source attribution covering the whole China during the COVID-19 pandemic. The COVID-19 pandemic disrupted human activities and lead to abrupt reductions in anthropogenic emissions. This study first investigated the source contributions to $PM_{2.5}$ over various regions covering the whole China during the COVID-19 pandemic. We pay attention not only to local emissions, but also to the impacts from regional and foreign transport of aerosols."

In the revised manuscript, we added an additional experiment to better reflect variations of contributions from local/nonlocal sources to aerosol pollutions during this period with low emission levels. "The anthropogenic emissions used in the baseline simulation are derived from the MEIC (Multi-resolution Emission Inventory of China) inventory (Zheng et al., 2018), referred to here as the Baseline experiment. While emissions for the other countries use the SSP (Shared Socioeconomic Pathways) 2–4.5 scenario data set under CMIP6 (the Coupled Model Intercomparison Project Phase 6). Emissions in year 2017 are used as the baseline during the simulation period considering the time limit of MEIC inventory."

"To highlight the roles of regional and foreign transport, the differences between Covid and Baseline simulations in relative contributions to $PM_{2.5}$ burden from local, region (RCN) and foreign (ROW) emissions are given in Figure S1. During the COVID-19 period, the local and RCN emission contributions to $PM_{2.5}$ were 1–4% lower than that in Base experiment over NCP and NEC. In Eastern China, the contribution from the local emissions decreased by 3–4% compared with Base experiment, while the contribution from ROW increased by more than 5%. In Southern China, 50–70% of the $PM_{2.5}$ burden is contributed by emissions from ROW in Base experiment. During the COVID-19 period with low emission levels, the contribution from ROW to $PM_{2.5}$ burden in Southern China had an increase of more than 5%. It indicates that the important role of transboundary transport needs to be considered when controlling local emissions to improve air quality in the near future."

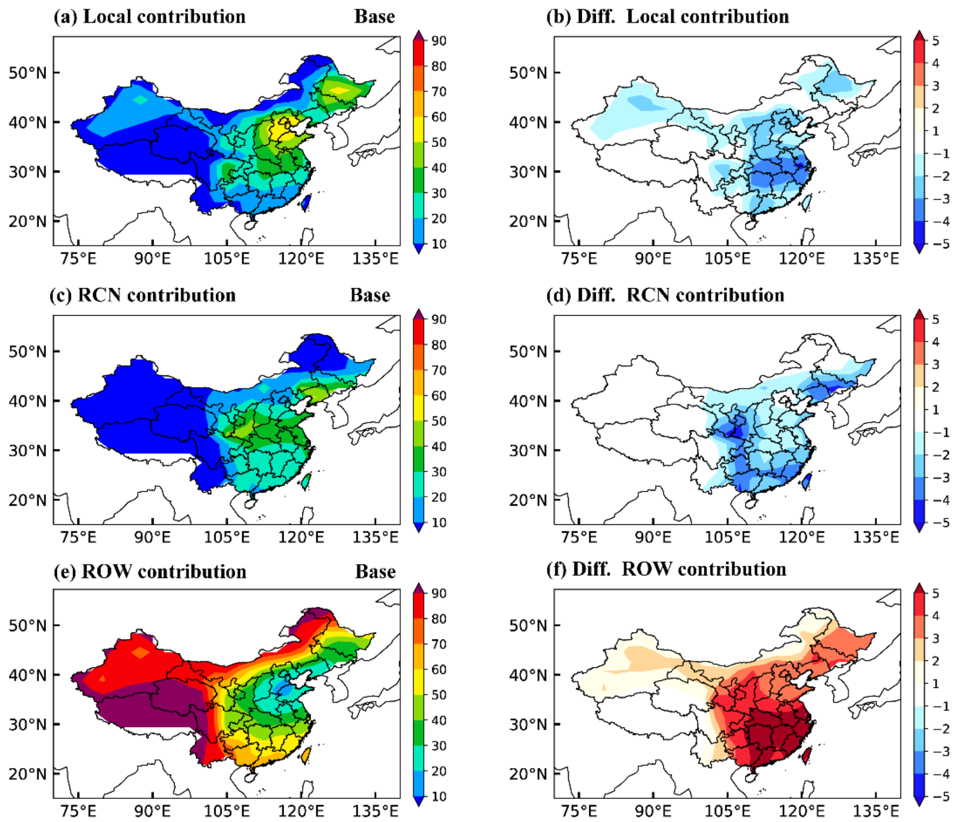

Figure S1. Relative contributions (%) in Baseline simulation (left) and differences in relative contributions (%) between Covid and Baseline simulations (right) of local emissions (top), the emissions from the rest of China (RCN) (middle) and all sources outside China (rest of the world, ROW) (bottom) to $PM_{2.5}$ column burden in February 2020.

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