Responses to Review #1

The manuscript by Yang et al. analyzes the meteorological characteristics and processes of severe ozone pollution events in four major cities in China using the GEOS-Chem model, and examines the historical and future changes of the ozone-favorable meteorological characteristics from ERA5 re-analyses and CMIP6 simulation results. The topic is within the scope of ACP. The methods are valid and the findings are valuable for understanding the historical and future change of ozone pollution in China. In general, it is a concise and well-written manuscript. I recommend publication after some clarification.

We thank the reviewer for the helpful 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 an effort to take into account all the comments raised here.

1. Introduction: I recommend further introducing what is missing in the above studies and what this study adds on then.

Response:

Thank you for the suggestion. We have now added the novelty of this study as following:

"As mentioned above, many previous studies have examined the meteorological characteristics of O_3 pollution in China. However, they focused on O_3 pollution over limited regions in China in each study (e.g., the North China Plain, southern China). These studies only examined the meteorological characteristics of O_3 pollution in a short time period due to the lack of observational data and did not consider the historical and future trends of these meteorological factors. In this study, the meteorological characteristics conducive to severe O_3 pollution in several polluted areas of China, including the North China Plain (NCP), Yangtze River Delta (YRD), Sichuan Basin (SCB), and Pearl River Delta (PRD), are respectively investigated based on the observed surface O_3 concentrations, reanalysis data, and GEOS-Chem model simulations. Besides, the contributions from various chemical and physical processes inducing regional O_3 pollution are quantified using an integrated process rate (IPR) analysis method. The historical changes in these meteorological factors favoring severe O_3 pollution over 1980–2019 are provided. Moreover, variations in future meteorological patterns during 2021–2100 leading to severe O_3 pollution in China are presented under the sustainable and high forcing scenarios according to the multi-model data from the Coupled Model Intercomparison Project Phase 6 (CMIP6)."

2. Table 1: It is quite interesting to see that ozone chemical net production is negative in Chengdu and Guangzhou. This requires some further discussions. Showing some detailed patterns of these diagnostics terms might be helpful. Is it possibly due to the relatively coarse resolution of the simulation (2x2.5)? It might be helpful to discuss the possible influence of model resolution on model diagnostics.

Response:

We agree with the reviewer that the relatively coarse model resolution could cause biases in the model results and diagnostics, since that the SCB (102.5°–105°E, 30°–32°N) and PRD (110°–115°E, 22°–26°N) for calculating diagnostics only cover one and four grid boxes, respectively.

We have now discussed it as "Note that, the chemical production of tropospheric O_3 decreased in SCB and PRD during the severe polluted months. It could have been biased by the relatively coarse model resolution in this study (2° latitude × 2.5° longitude), since that the SCB and PRD for calculating the chemical and physical processes only cover limited grid boxes. Further studies should be performed using a model with finer resolution or a nested simulation method."

3. Figure 8 (and future projection) uses the spatial correlation of SLP and GPH for each year with that in the targeted ozone pollution month to examine the similarity of weather patterns. While this is mostly sound and efficient, I wonder whether the magnitude of SLP and GPH should be considered. In addition, it should be clear whether the correlation is calculated for each month in 1980-2020 to compare with the targeted ozone pollution month.

Response:

In the analysis of the meteorological characteristics conducive to severe O_3 pollution, temperature at 2m (T2m) and surface relative humidity (RH), sea level pressure (SLP) and geopotential height (GPH) at 500 hPa are adopted. For T2m and RH, the changes in the magnitude of these two variables are presented because they are related to the chemical production in a specific location. For SLP and GPH, the spatial correlation over East Asia and Western Pacific (EAWP, 90°–160°E, 20°–60°N) between the variable in targeted O_3 polluted month and the month in other years is calculated, because they are more related to the large-scale circulation over a broad region. Therefore, the number of high correlation years are more suitable for SLP and GPH rather than the magnitude. This method for SLP and GPH has been used in many previous studies (Li et al., 2018; Yang et al., 2021). Also, accompanied with global warming, the magnitude of SLP and GPH could also change with time. We have added the references in the manuscript. The correlation is calculated for the same month as the targeted month in 1980-2020 to compare with the targeted ozone pollution month. We have clarified as "Similar to the analyzing method used in previous studies (Li et al., 2018; Yang et al., 2021), the SLP and 500 hPa GPH over East Asia and Western Pacific in the same month of each year similar to those during the severe polluted months in both SCB and PRD have increased (2000-2019 versus 1980-1999)".

4. Line 161：misspelling of “simulation”

Response:

Revised

References:

Li, K., Liao, H., Cai, W., and Yang, Y.: Attribution of anthropogenic influence on atmospheric patterns conducive to recent most severe haze over eastern China, Geophys. Res. Lett., 45, 2072–2081, https://doi.org/10.1002/2017gl076570, 2018.

Yang, Y., Zhou, Y., Li, K., Wang, H., Ren, L., Zeng, L., Li, H., Wang, P., Li, B., and Liao, H.: Atmospheric circulation patterns conducive to severe haze in eastern China have shifted under climate change, Geophys. Res. Lett., 48, e2021GL095011, https://doi.org/10.1029/2021GL095011, 2021.