Response to Reviewer #3's comments

First of all, we would like to thank the Reviewer #3's comments and suggestions, which improved significantly the presentations and interpretations of our revised manuscript. In the revised article, we have addressed all comments from the Reviewer. Our point-by-point responses to the Reviewer's comments are outlined below. The original comments are shown in italics and our responses are given in normal fonts.

Review "Associations of interannual variation of Summer Tropospheric Ozone with Western Pacific Subtropical High in China from 1999 to 2017" by Zhang et al.

General

Surface ozone can post great threats to public health and vegetation growth. Ozone pollution in China has become a severe environmental issue in the recent decades. Surface ozone varies at different time scale from diurnal to interannual scales. The interannual variation and long-term trend of surface ozone are difficult to investigate partially because of lack of long term observations. Therefore, numerical models become a powerful tool in addressing this issue. In this work, Zhang et al. used the Weather Research and Forecasting model coupled with Chemistry, WRF- Chem, to investigate interannual variations in summertime ozone for 18 years from 1999-2017 over China. Through EOF analysis and sensitivity simulation experiments, they linked summer ozone variation with the interannual variation in the Western Pacific Subtropical High (WPSH). The topic is suitable to Atmospheric Chemistry and Physics. The research ideas are innovative. The analysis are in some depth. The results are meaningful and interesting.

I provide the following comments/suggests for the authors to consider when revising their paper.

Response: We thank the Reviewer's positive and encouraging comments which help us improve this article considerably. We have made every effort to address the Reviewer's comments and questions.

Point-by-point responses:

This is a simulation-based analysis. Therefore, how WRF-Chem performs is critical. The authors presented some validation validations at short time scales (Figure S1). How about at interannual scale? How well the model can capture the interannual variation and trend is most relevant to this work. The authors can use the recent (since 2013) surface measurement for this validation.

Response: Following the Reviewer's comment, in the revised paper, we have extended model evaluation from 2016 to 2016 to 2017 by adding on more year O_3 sampling data in 2017. The routine O_3 measurements started in 2013 in China but there were large uncertainties in measured data due to manual intervention before 2016. Considering that present study focused on interannual and longer-term summer mean O_3 variation associated with the summer WPSH, we have replaced hourly data by daily concentrations. Results reveal better agreement between modeled and measured concentrations, as referred in revised SI Text 1 and Fig. S1.

When the authors explored the underlying mechanisms for the linkage between summertime surface ozone and WPSH, they considered air temperature, precipitation, and wind (Abstract, Figures 5 and 6). Radiation is missing. As known, radiation is one of the most important drivers for surface ozone formation. Therefore, please take radiation into consideration.

Response: We agree with the Reviewer! In the revised paper, we have added a new Fig. S9 in SI showing the correlation coefficients between surface incoming solar radiation flux and O_3 concentration and WPSH-I1 from 1999 to 2017 across China. We also added corresponding discussion in main text.

There are many differences in the correlation of a WPSH index with surface ozone between Figure 4 and Figure 8a, which are puzzling. Can the authors please explain the differences?

Response: Likely we did not described clearly. Figure 4 shows the correlations between modeled O_3 and WPSH under model scenario 1 with variable meteorology and precursor emissions, whereas Figure 8 illustrates correlations subject to model scenario 2 with fixed precursor emissions and variable meteorology. For example, Figure 4 shows a negative correlation between modeled summer O_3 concentration from model scenario 1 and WPSH-I2 time series in the YRD under model scenario 1 but model scenario 2 yields a positive correlation (Fig. 8b). Since model scenario 1 took annually-altered O_3 precursor emissions into consideration, the negative correlation suggests that declining precursor emissions from 1999 to 2017 in the YRD overwhelmed the WPSH effect. After removed the effect of precursor emissions in model scenario 2 subject to fixed precursor emissions, the meteorology associated with the WPSH would help enhance O_3 concentrations in this region. Therefore, the spatial distribution patterns of the two figures are significantly different.

This point has been added to the revised manuscript

One key figure seems missing: what are the spatial distributions of the composite anomalies of surface ozone in positive and negative phases of WPSH from the model simulations? How do the two distributions differ? The authors can compare these differences with those in recent observations (select two years with the largest difference in the WPSH index) and discuss your observations.

Response: We thank the Reviewer's advice. We did estimate the composite anomalies of surface O_3 but didn't present them in the paper. Considering that precursor emissions should dominate O_3 levels, it is not straightforward to identify signals from the O_3

response to WPSH during its positive and negative phase from precursor emissions. One way is to calculate the composite anomalies O_3 in positive and negative phase of the WPSH under model scenario 2 with fixed precursor emissions but the results cannot be compared to observations because measured O_3 concentrations are determined primarily by its precursor emissions.

The authors can also briefly discuss relative importance of other climate modes, such as ENSO, and the East Asian monsoon to the interannual variation in surface ozone over China, comparing with WPSH.

Response: In Introduction, we have discussed the relationships between O_3 and other interannual climate modes. Following the Reviewer's comment, we have rephrased text as "Using modeled summer O_3 time series across China from 1999 to 2017, we have examined the response of gridded summer O_3 concentrations to the East Asian Summer Monsoon Index (EASMI), Nino indices, and western North Pacific subtropical high index (WPSH-I), the three climate modes influencing significantly the summer weather and climate in China, on an annual basis in the six major UAs in China (Zhang et al., 2022). The correlation coefficients between the summer O_3 concentrations and the three climate modes from 1999 to 2017 are 0.54 (WPSH-I, $p=0.016$), 0.38 (Nino indices, $p=0.105$), and 0.27 (EASMI, $p=0.267$), respectively. The results revealed that interannual changes in summer O_3 averaged over these UAs were more significantly associated with the WPSH-I among three atmospheric teleconnection patterns. The finding motivates us to carry out more broad and deep investigations of the associations between the long-term change in summer O_3 and the WPSH, aiming to shed new light on the extent of the impact of climate variation on O_3 trends in urban China."

Both abstract and conclusions lack of quantitative information (only two pieces of information in abstract, zero piece of information in conclusions). Please add more quantitative discussion.

Response: Following the Reviewer's suggestion, we have revised Abstract and Conclusion sections and added more quantitative information.

Minor

Figure 1, please show the domain for the subregions studied (CY, CC, MYR, YRD, PRD, and BTH) in this figure or another figure.

Response: Done!

Figures 4b and 8, please only show significant correlations, or indicate where the correlation is significant ($p<0.05$).

Response: Following the Reviewer's advice, we have marked those significant correlations ($p<0.05$) in Figure 4 and 8b.