1 Response to Reviewer #1's comments

1.1 1. The Pacific decadal oscillation which is also one of the main climate mode that can affect ENSO and indeed on the ozone concentrations. The authors didn't explain why other climate modes are not considered and why only three (Dipole mode Index, Southern Annual Mode and North Atlantic Oscillation) climate modes.

Response: We thank the reviewer for raising this point. We agree that the Pacific decadal oscillation (PDO) is an important climate mode. However, as we mainly focus on the impacts of ENSO on interannual time scale, we have not included the PDO in the analysis.

We added the following sentences to Section 2.2 to clarify this point:

"In this study, the confounding factors are limited to three major climate modes (i.e., DMI, SAM and NAO) as these modes are crucial to global climate variability on interannual time scales (Delworth et al., 2016; Hurrell et al., 2003; Kripalani et al., 2009; Luo et al., 2012; Raphael and Holland, 2006). Furthermore, alterations in these climate modes may influence the variations of ENSO (Cai et al., 2019; Ha et al., 2017; Le et al., 2020; Le and Bae, 2019)."

1.2 2. Try to elaborate mainly the common schemes in the Atmospheric Chemistry Modules that are in the models (other than the three models BCC_CSM2_MR, IPSL_CM6A_LR and MPI_ESM1_2_LR) as the behavior of these models in connection to the response of ENSO on ozone variation is similar.

Response: We thank the reviewer for raising this point. We added the following sentences to Section 2.1 and Section 4 to clarify this point:

"In Table 1, the models equipped with an Atmospheric Chemistry module are fully coupled where the chemistry scheme is associated with the physics of the atmospheric model, allowing for comprehensive consideration of interactions between climate variations, interactive chemistry, and carbon cycle (Emmons et al., 2020; Michou et al., 2020; Wu et al., 2019)."

"In these models, ozone variations are prescribed using observational data (Lurton et al., 2020; Wu et al., 2019), and it is expected that the response of ozone variation to atmospheric circulation and ENSO is not significant."

1.3 3. The Text S1 which explains about the method that has been adopted should be mentioned under the method section 2.2 rather than in the supplement. It helps the reader to have a quick through of the methodology adopted in the study.

Response: We thank the reviewer for this suggestion. We moved Text S1 to Section 2.2 of the main text.

1.4 4. Why did you consider only 1000 hPa, 850 hPa, 500 hPa and 300 hPa ? Are these pressure levels enough to represent the respective atmospheric region of the atmosphere (like middle troposphere, upper troposphere). As ENSO is responsible for changes in winds and circulation patterns. It is also expected to have impact on the transport of ozone from the lower troposphere to upper troposphere and lower stratosphere. It would be interesting if you can check if the features are same in the upper levels (above 300 hPa just below the tropopause)

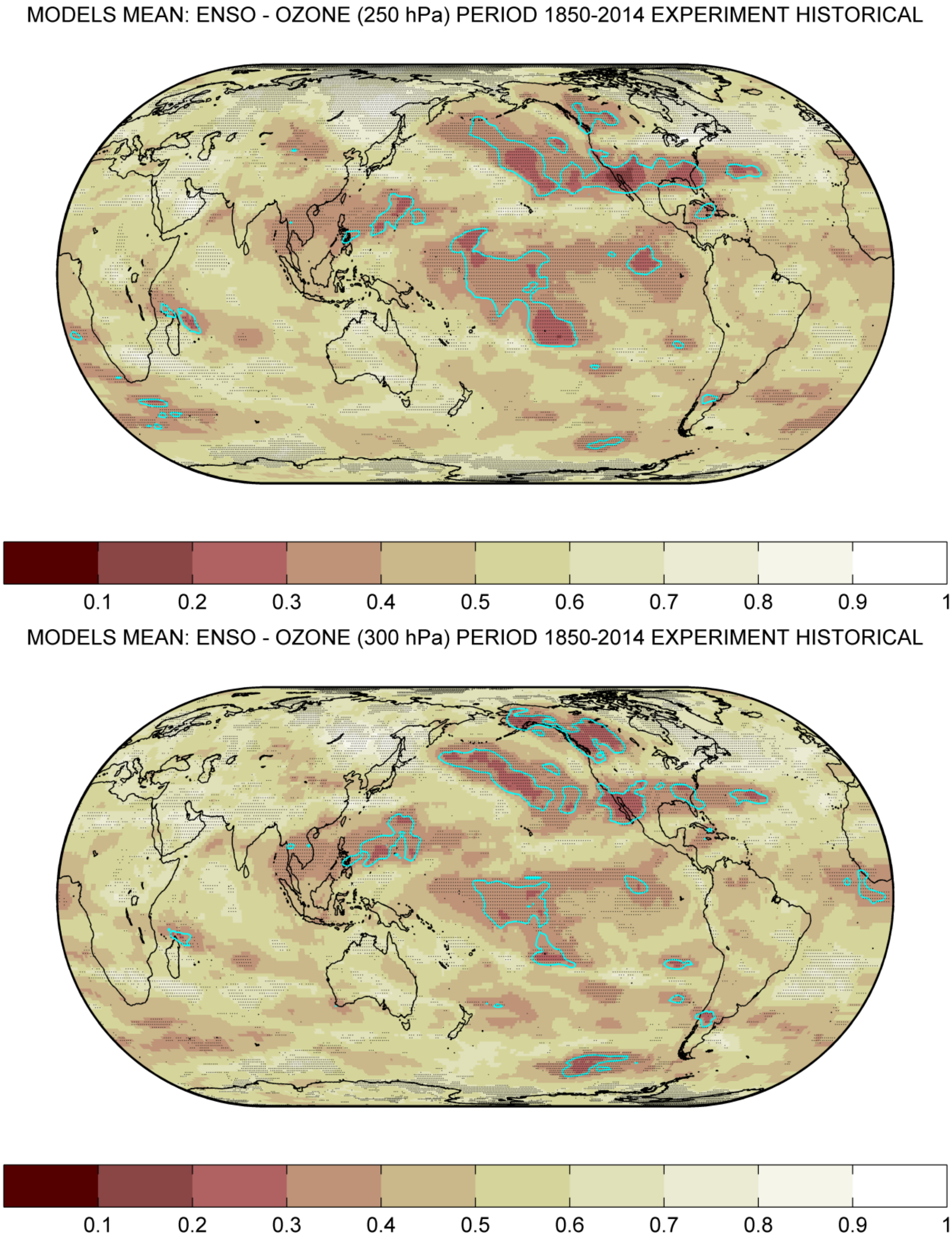
Response: We thank the reviewer for raising this point. In our opinion, the selected pressure levels can represent much of the atmosphere as supported by the results described in Figure 2. In Figure 2, there might be distinct impacts of ENSO on ozone over the lower, middle, and upper troposphere.

Below we show the analysis at 250 hPa. At this pressure level, the regions from 60N-90N are in the lower stratosphere, while the regions from 90S-60N are in the upper troposphere (Griffiths et al., 2021). Figure R1 below shows that the pattern of ENSO impacts for the analysis at 250 hPa is similar to the analysis at 300 hPa. Hence, we conclude that there is no significant change in ENSO impacts on ozone at the tropopause, though additional analyses might give clearer answer.

We added the following sentences to Sections 3 and 4 to discuss this point:

“Further analysis (not shown) indicates that the patterns of ENSO impacts on ozone at 250 hPa are similar to those at 300 hPa. This implies that the response of ozone variation to ENSO might remain consistent across the upper troposphere, the tropopause, and the lower stratosphere.”

“In addition, as the tropopause may vary depending on different latitudes (Griffiths et al., 2021), it is essential to conduct further analyses that specifically address the impacts of ENSO on ozone concentrations across the upper troposphere, the tropopause, and the lower stratosphere.”



MODELS MEAN: ENSO - OZONE (250 hPa) PERIOD 1850-2014 EXPERIMENT HISTORICAL

MODELS MEAN: ENSO - OZONE (300 hPa) PERIOD 1850-2014 EXPERIMENT HISTORICAL

Figure R1. Map of multi-model mean probability for the absence of Granger causality from ENSO to annual ozone concentrations for the historical experiment over the 1850-2014 period at 250 hPa (upper) and 300 hPa (lower).

1.5 Line Nos.:42:43: Did you check if the findings obtained using CMIP6 and CMIP5 ? If so where did you find the changes that resulted in the current result?

Response: We thank the reviewer for raising this point. We have not tried to add the analyses of CMIP5 models because there is limitations in these models (Emmons et al., 2020; Michou et al., 2020).

Further explanation is added to Section 2.1:

“For example, the simulation of tropospheric ozone in CESM2 models is improved in comparison to previous model versions (Emmons et al., 2020). In addition, CMIP6 models are capable of simulating long-term changes in surface ozone levels and recent increasing trends in tropospheric ozone (Griffiths et al., 2021; Turnock et al., 2020).”

1.6 Line Nos.: 51: The list of the models mentioned in Table S1 should be shifted to the main manuscript instead of supplement.

Response: We thank the reviewer for this suggestion. We moved Table S1 to Section 2.1 of the main text.

1.7 Line Nos. 53:55: The authors are suggested to explain little more on the findings of the cited papers rather than just citing the paper.

Response: We thank the reviewer for raising this point. We added the following sentences to Section 2.1 to clarify this point:

“For instance, CMIP6 models may underestimate ozone levels in the Southern Hemisphere and overestimate ozone levels in the Northern Hemisphere compared to observational data of recent past (Griffiths et al., 2021; Turnock et al., 2020; Young et al., 2018).”

“For example, the simulation of tropospheric ozone in CESM2 models is improved in comparison to previous model versions (Emmons et al., 2020). In addition, CMIP6 models are capable of simulating long-term changes in surface ozone levels and recent increasing trends in tropospheric ozone (Griffiths et al., 2021; Turnock et al., 2020).”

1.8 The Figures can be of more clarity (mainly the stippling in figures are not at all visible (for example Figure 1 (a)) are not visible clearly, The titles in the Figure 3 should be made little big)

Response: We thank the reviewer for this suggestion. We will provide higher resolution figures.

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