Replies to comments by Owen R. Cooper (TOAR Scientific Coordinator of the Community Special Issue) on:

Influence of nitrogen oxides and volatile organic compounds emission changes on tropospheric ozone variability, trends and radiative effect

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This review is by Owen Cooper, TOAR Scientific Coordinator of the TOAR-II Community Special Issue. I, or a member of the TOAR-II Steering Committee, will post comments on all papers submitted to the TOAR-II Community Special Issue, which is an inter-journal special issue accommodating submissions to six Copernicus journals: ACP (lead journal), AMT, GMD, ESSD, ASCMO and BG. The primary purpose of these reviews is to identify any discrepancies across the TOAR-II submissions, and to allow the author teams time to address the discrepancies. Additional comments may be included with the reviews. While O. Cooper and members of the TOAR Steering Committee may post open comments on papers submitted to the TOAR-II Community Special Issue, they are not involved with the decision to accept or reject a paper for publication, which is entirely handled by the journal's editorial team.

Comments regarding TOAR-II guidelines:

TOAR-II has produced two guidance documents to help authors develop their manuscripts so that results can be consistently compared across the wide range of studies that will be written for the TOARII Community Special Issue. Both guidance documents can be found on the TOAR-II webpage: https://igacproject.org/activities/TOAR/TOAR-II

The TOAR-II Community Special Issue Guidelines: In the spirit of collaboration and to allow TOAR-II findings to be directly comparable across publications, the TOAR-II Steering Committee has issued this set of guidelines regarding style, units, plotting scales, regional and tropospheric column comparisons, and tropopause definitions.

The TOAR-II Recommendations for Statistical Analyses: The aim of this guidance note is to provide recommendations on best statistical practices and to ensure consistent communication of statistical analysis and associated uncertainty across TOAR publications. The scope includes approaches for reporting trends, a discussion of strengths and weaknesses of commonly used techniques, and calibrated language for the communication of uncertainty. Table 3 of the TOAR-II statistical guidelines provides calibrated language for describing trends and uncertainty, similar to the approach of IPCC, which allows trends to be discussed without having to use the problematic expression, "statistically significant".

Response: We sincerely thank the reviewer for the meticulous review, constructive comments, and valuable suggestions, which have significantly enhanced the quality of the manuscript. As suggested by the reviewer, we have carefully addressed all suggestions and incorporated the necessary revisions. We appreciate the reviewer's time and effort in improving our work.

General comments:

In the list of authors, please check the spelling and affiliation of co-author Eric Le Flochmoen

Response: Spelling and Affiliation is corrected in the revised manuscript [L5].

"America" is a vague term. Please specify if you are talking about North America, Central America, or South America, or a sub-region.

Response: The term 'America' is replaced with 'North America' in the revised manuscript [L48].

Line 80 "Global Observing System" should be, "In-service Aircraft for a Global Observing System"

Response: Corrected in the revised manuscript [L83].

Line 83 Given that the IAGOS record only extends back in time to 1994, Fiore et al. 2022 could only base their assessment of long-term trends (1950-2014) on the model simulations, and a few limited surface ozone records.

Response: This sentence is corrected in the revised manuscript [L87].

Lines 87-90 With only 5 years of OMI/MLS data available, Cooper et al. (2014) did not assess trends over such a short time period. But they did assess the average tropospheric ozone burden by latitude.

Response: This sentence is corrected in the revised manuscript [L92].

Line 97-111 Global ozone trends were sufficiently summarized at the beginning of the Introduction, based on the findings of IPCC AR6. This particular paragraph then repeats some of the IPCC findings by citing some of the same papers summarized by IPCC. It also cites the trends reported by Cooper et al. 2014, which are now out of date. The discussion in this paragraph is also fairly disorganized. As the paper is already quite long, I recommend that this paragraph be deleted.

Response: This paragraph is removed from the revised manuscript.

Lines 132-134 The most up-to-date estimates of ozone ERF are provided by Forster et al. 2021 and Forster et al. 2024, so why report the out-of-date findings by Myhre et al. 2013 and Skeie et al., 2020?

Response: The lines quoting the results of Myhre et al. 2013 and Skeie et al., 2020 are removed in the revised manuscript.

Line 137 It would be more accurate to say that your analysis addressed ozone's radiative effect, rather than radiative forcing. Lu et al. (2024) just submitted a paper to the TOAR-II Community Special Issue, and it should be available for the open comment period very soon. This paper is relevant to your study as it uses models to understand the drivers of increasing ozone across

East and Southeast Asia. The reference is listed below. Another recent submission to the TOAR-II Community Special Issue that is relevant to your analysis of ozone's radiative effect is Collins et al. (2024).

Response: The term 'Radiative forcing' is replaced with 'radiative effect' in the revised manuscript [L145].

Figure 3 This is a very interesting figure, but it is ignoring ozone changes over the oceans. Why leave out the atmosphere that lies above the oceans, which cover 2/3 of the surface of the Earth? I think most readers would like to see what happens to ozone downwind of East Asia, for example, and these oceanic regions should be shown, as has been done for Figure 4. I have similar comments regarding Figure 5.

Response: As suggested by the reviewer, the Ocean mask in Figures 03 and 05 are removed in the revised manuscript.

At the time of this writing, one of the anonymous referees has posted a set of comments, which are thorough and constructive. However, I have to disagree with this comment: "The most obvious explanation for the positive ozone trend - climate warming - is not discussed in this study, which is a major shortcoming." Fadnavis et al. only assessed trends over a short 21-year period (1998-2021), and according to the global temperature rate of increase assessed by IPCC AR6, this corresponds to a relatively small temperature increase of about 0.3 to 0.4 C. As shown by Zanis et al. (2022), an ozone climate penalty doesn't emerge until global temperatures increase by 2-3 C, and even then its only at the surface in high emissions regions. Given that higher temperatures increase the water vapor content of the atmosphere, which reduces ozone's lifetime, the main impact of climate change is to reduce ozone in remote regions.

Response: We appreciate the reviewer's thorough assessment and valuable insights regarding the role of climate warming in ozone trends. Their careful evaluation has helped refine our discussion, and we have incorporated these points into the revised discussion section.

References

Collins, W. J., O'Connor, F. M., Barker, C. R., Byrom, R. E., Eastham, S. D., Hodnebrog, Ø., Jöckel, P., Marais, E. A., Mertens, M., Myhre, G., Nützel, M., Olivié, D., Bieltvedt Skeie, R., Stecher, L., Horowitz, L. W., Naik, V., Faluvegi, G., Im, U., Murray, L. T., Shindell, D., Tsigaridis, K., Abraham, N. L., and Keeble, J.: Climate Forcing due to Future Ozone Changes: An intercomparison of metrics and methods, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-3698, 2024.

Lu, Xiao, et al. (2024), Tropospheric ozone trends and attributions over East and Southeast Asia in 1995- 2019: An integrated assessment using statistical methods, machine learning models, and multiple chemical transport models, submitted to ACP

Zanis, P., Akritidis, D., Turnock, S., Naik, V., Szopa, S., Georgoulias, A.K., Bauer, S.E., Deushi, M., Horowitz, L.W., Keeble, J. and Le Sager, P., 2022. Climate change penalty and

benefit on surface ozone: a global perspective based on CMIP6 earth system models. Environmental Research Letters, 17(2), p.024014.