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Comment on acp-2021-689

Anonymous Referee #1

Referee comment on "Tropospheric ozone changes and ozone sensitivity from the present day to the future under shared socio-economic pathways" by Zhenze Liu et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-689-RC1, 2021

This manuscript explores the sensitivity of ozone production in a future climate across three possible emissions scenarios. The paper is extremely well written, the figures and tables are clear and self-explanatory and the conclusions are sound and supported by the evidence. I have a few minor comments, mainly focused on the need to cite previous work, and to present the findings in the context of the new conclusions by IPCC AR6.

The paper would benefit from some discussion that places these results in the broad context of the recent findings of IPCC AR6. I realize that AR6 was not published when this paper was submitted, so AR6 could not be referenced. But now that AR6 is publicly available, a comparison is warranted, especially in terms of Chapter 6, Section 6.5.1, "Effect of climate change on ozone". The broad message from this new analysis is that ozone in the mid-21st century will be lower across the USA than it is today, under all three scenarios. Presumably, the primary cause is the decrease in regional US emissions of NOx. However, part of the explanation could also be due to a shorter ozone lifetime in a warmer, more humid future. How much of this decrease is due to emissions changes and how much is due to climate change? Along these same lines, what is the impact of future heat waves, which are expected to be more intense in the future? Stronger heat waves will lead to episodic surface ozone pollution events. Will these future pollution episodes be more intense than present day events? Is the average decline in ozone masking a few extreme high ozone events in the future?

In the Introduction (lines 36-41) several of the papers cited in terms of describing recent ozone trends are out of date. For example, the data analysis in Lefohn et al. (2008) stops in 2005 so the paper does not report the strong decreases of ozone in the eastern USA that occurred after 2004. The paper by Akimoto et al. (2003) does not even report observations from the 21st Century. Ohara et al., 2007 is also out of date. Current papers are:

Simon, H, Reff, A, Wells, B, Xing, J and Frank, N (2015), Ozone Trends Across the United States over a Period of Decreasing NOx and VOC Emissions. Environ. Sci. Technol 49: 186–195. DOI: https://doi.

org/10.1021/es504514z

Strode, S. A., J. M. Rodriguez, J. A. Logan, O. R. Cooper, J. C. Witte, L. N. Lamsal, M. Damon, B. Van Aartsen, S. D. Steenrod, and S. E. Strahan (2015), Trends and variability in surface ozone over the United States, J. Geophys. Res. Atmos., 120, 9020–9042, doi:10.1002/2014JD022784

Lu, X., Zhang, L., Wang, X., Gao, M., Li, K., Zhang, Y., Yue, X. and Zhang, Y., 2020. Rapid increases in warm-season surface ozone and resulting health impact in China since 2013. Environmental Science & Technology Letters, 7(4), pp.240-247.

Chang, K-L, I. Petropavlovskikh, O. R. Cooper, M. G. Schultz and T. Wang (2017), Regional trend analysis of surface ozone observations from monitoring networks in eastern North America, Europe and East Asia, Elem Sci Anth., 5:50, DOI: http://doi.org/10.1525/elementa.243

Tarasick, D. W., I. E. Galbally, O. R. Cooper, M. G. Schultz, G. Ancellet, T. Leblanc, T. J. Wallington, J. Ziemke, X. Liu, M. Steinbacher, J. Staehelin, C. Vigouroux, J. W. Hannigan, O. García, G. Foret, P. Zanis, E. Weatherhead, I. Petropavlovskikh, H. Worden, M. Osman, J. Liu, K.-L. Chang, A. Gaudel, M. Lin, M. Granados-Muñoz, A. M. Thompson, S. J. Oltmans, J. Cuesta, G. Dufour, V. Thouret, B. Hassler, T. Trickl and J. L. Neu (2019), Tropospheric Ozone Assessment Report: Tropospheric ozone from 1877 to 2016, observed levels, trends and uncertainties. Elem Sci Anth, 7(1), DOI: http://doi.org/10.1525/elementa.376

Gaudel, A., O. R. Cooper, K.-L. Chang, I. Bourgeois, J. R. Ziemke, S. A. Strode, L. D. Oman, P. Sellitto, P. Nédélec, R. Blot, V. Thouret, C. Granier (2020), Aircraft observations since the 1990s reveal increases of tropospheric ozone at multiple locations across the Northern Hemisphere. Sci. Adv. 6, eaba8272, DOI: 10.1126/sciadv.aba8272

Table 2 indicates that methane will be about 1364 ppb in 2050 under the SSP3-7.0-lowCH4, which is far lower than the present-day value of about 1890 ppb (https://gml.noaa.gov/ccgg/trends_ch4/). This would require major reductions in CH4. To provide context for the reader, can you let us know when methane was last at such a low level in the atmosphere? I'm guessing that it would be sometime around the 1960s based on Figures 2.4 and 2.5 of IPCC AR6. According to Figure 2.5 of IPCC AR6, methane was approximately 1500 ppb in the 1970s, based on in situ observations. According to Figure 2.4 of IPCC AR6, methane was about 1000 ppb in the early 20th century (perhaps around 1940?).

It would help to briefly mention the significance of the term "regional rivalry" when describing the future scenarios. This term is mentioned twice in the paper, so it must have some importance, but I really have no idea what it means.

When using the TOAR data products, the following data link should be cited, in addition to the peer-reviewed publication by Schultz et al. (2017):

Schultz, M. G, et al. (2017): Tropospheric Ozone Assessment Report, links to Global surface ozone datasets. PANGAEA, https://doi.org/10.1594/PANGAEA.876108

Line 321

globe should be global

Figure 6 and elsewhere

When reporting trace gas values in units of ppb, one cannot use the term concentration, which is mass per volume. The expression mixing ratio must be used.