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Reply to 2nd Comment of Anonymous Referee #1: acp-2022-424-RC2

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Author comment on "Technical note: Northern midlatitude baseline ozone – long-term changes and the COVID-19 impact" by David D. Parrish et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-424-AC2, 2022

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We thank the referee for continuing the discussion of our submitted paper. This 2nd comment helps to clarify the difference between the interpretations presented in earlier publications and that in our manuscript.

Here we briefly respond (*in italics*) to the initial general statement and the three bulleted points (copied in plain text) that the referee makes in that 2nd comment:

- "So there are no new data and there is no significant new information over what is already published in Parrish et al. (2020).
- Using old data and information, the authors come to the conclusion "that the COVID-19 restrictions had a much smaller impact on background tropospheric ozone in 2020 than previously reported". Based on old data and information only, this conclusion is in clear contradiction to a large number of more recent scientific publications, …"

Science is not merely the accumulation of new data. Indeed, science progresses through the continued reinterpretation of old and new data, and concerning the question at hand, namely the impacts of the COVID-19 lockdowns on tropospheric ozone, our submission represents a novel interpretation of the available data. We disagree that there is no "new information" in our submission as posited by the referee. Our considered analysis of the published data shows that while many have already published what the referee asserts is settled science, there is a significant body of evidence that indicates that these accepted conclusions may have been overstated because of two important points that we discuss in our submission. We urge the editors and reviewers to focus on the scientific validity of our arguments, and whether they correctly open the possibility of reinterpreting the conclusions of previously published studies. Logical argumentation based on precedent in the literature is not scientific; this is why Richard Feynman famously declared that "science is the belief in the ignorance of experts."

- The COVID-19 related lockdowns resulted in very significant emission reductions worldwide.

We agree qualitatively with this point.

- These emission reductions resulted in significant reductions of ozone in the free troposphere, as evidenced by studies based on observations, and by studies based on model simulations.

We agree only that observations do show that 2020 ozone in the free troposphere was lower than the 2000 to 2020 climatological mean, which Steinbrecht et al. (2021) chose as their reference. However, we demonstrate that Steinbrecht et al. (2021) overestimated the magnitude of the reduction due to the COVID-19 related emission reduction, because their chosen reference neglects the non-linear aspects of the long-term ozone changes that are ongoing throughout the northern midlatitude troposphere.

- A contribution from the 2020 Arctic ozone hole is also not new - this is mentioned already, e.g. in Steinbrecht et al. (2021), or Bouarar et al. (2021).

A reduced contribution of STE to tropospheric ozone due to the record large 2020 Arctic ozone depletion is potentially a second reason that Steinbrecht et al. (2021) overestimate the magnitude of the ozone reduction. Although they do mention this issue, they do not include its quantitative impact even though their Figure 3 shows that large negative ozone anomalies were present in the lower stratosphere in 2020. Further, computer modeling very likely inadequately quantifies the influence of the Arctic ozone depletion. A review of global model sources of O_3 from the stratosphere to the troposphere by Young et al. (2018) found substantial spread among model estimates, and concludes quite stringently that "model results should be approached critically", which is exactly what we are calling on our peers reviewing this submission to do.

In summary, there are substantial differences in the interpretation of the long-term changes in tropospheric ozone at northern mid-latitudes. Parrish et al. (2020) quantify significant non-linear behavior, with a substantial decrease since the mid-2000s. Neglect of this decrease led Steinbrecht et al. (2021) to overestimate the magnitude of the COVID-19 related impact.

Notably, this is not simply an academic disagreement. As we discuss in our paper, the ongoing decrease in tropospheric ozone has substantial air quality implications, since baseline ozone has a major impact on surface urban and rural ozone concentrations. Thus, accurate characterization of these changes is important; our paper does indeed "provide the substantial advances and general implications for the scientific understanding, required for an ACP research article."

Finally, we emphasize a rather unique aspect of this discussion by quoting the final sentence from our abstract: "Analysis of baseline ozone measurements over several years following the COVID-19 impact is expected to provide a firm basis for resolving the inconsistencies between the two views of long-term northern midlatitude ozone changes and better quantifying the COVID-19 impact." Thus, a resolution of the disagreement is in the offing.

Additional Reference:

Young, PJ, et al. 2018 Tropospheric Ozone Assessment Report: Assessment of global-scale model performance for global and regional ozone distributions, variability, and trends. Elem Sci Anth, 6: 10. DOI: https://doi.org/10.1525/elementa.265