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Comment on acp-2022-424

Anonymous Referee #2

Referee 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-RC3, 2022

General comments

This paper discusses the issues in detecting the long-term trends of northern midlatitude ozone and the related consequences in quantifying the COVID-19 impact on ozone levels in 2020. Due to long-term variations in emissions of ozone precursors, tropospheric ozone has been changing substantially since the 1950s. Temporal changes of ozone (in particular surface ozone) are found highly dependent on locations because of the differences in local/regional emissions as well as meteorological/geographical conditions. Therefore, it is impossible to obtain a consistent picture of long-term change of ozone for all sites and regions. Nevertheless, there have been efforts to establish a relatively consistent spatiotemporal variation of baseline ozone (meaning free of recent continental influences). Baseline ozone levels were found to have a high degree of zonal similarity at northern midlatitudes, and increased nonlinearly by a factor of 2 during 1950-2000 and began to decrease around the mid-2000s (Junge, 1962; Logan et al., 2012; Parrish et al., 2012; 2014). This understanding of baseline ozone is referred by the authors as the "Conventional Wisdom". Least squares regression is a common way to quantify long-term trends of ozone concentrations. In view of the Conventional Wisdom, some studies (e.g., Logan et al., 2012; Parrish et al., 2012; 2014; 2017; 2020; 2021a; 2021b; Derwent et al., 2018; Derwent and Parrish, 2022) used quadratic functions in the regression, which well addressed the nonlinear long-term change of ozone. However, some recent studies (Gaudel et al., 2018; 2020; Tarasick et al., 2019; Cooper et al., 2020; Chang et al., 2022) disregarded the nonlinearity and estimated ozone trends using linear fits, obtaining much smaller positive or negative trends for varying periods. These recent studies are referred by the authors as the "Linear Trend View". The inconsistent ozone trends between the Conventional Wisdom and the Linear Trend View are caused by different treatments of historic ozone measurements. It is controversial which trend detection approach is superior. However, some recent publications take the climatological means of ozone as references, report larger negative anomalies of ozone in 2020 at a high mountain site (Cristofanelli et al., 2021) and in the northern hemisphere free troposphere (Steinbrecht et al., 2021; Clark et al., 2021; Chang et al., 2022) and attribute the negative anomalies to the COVID-19 impact. This is the critical issue raised in this paper. The authors review the results from the related publications, evaluate the reported 2020 ozone anomalies in the context of linear and nonlinear ozone trends, and show that the 2020 anomalies are well within the uncertainty range of the estimated 2020 baseline ozone level (extrapolation of their quadratic fit). They argue that even without the COVID-19 impact, the expected level of baseline ozone in 2020 would be 3.2±1.3 ppb lower than the reference value in 2000 and conclude that the COVID-19 impact on baseline ozone in 2020 was only -1.2±1.3 ppb estimated from the Conventional Wisdom instead of -4 ppb (Steinbrecht et al., 2021) or -3.7 ppb (Chang et al., 2022) from the Linear Trend View. The authors claim that the Conventional Wisdom estimate combined with the influence of the reported 2020 Arctic ozone depletion is sufficient to explain all of the 2020 ozone decrease without any impact from COVID-19 emission reductions. They also point out that a clear resolution of the inconsistencies between the Conventional Wisdom and the Linear Trend View is important for designing air quality improvement strategies in earlier developing economies and they emphasize the importance of cooperative, international emission control efforts in further ozone reductions.

Overall, I think this paper addresses some important issues in current researches of tropospheric ozone. The methods applied in this paper are acceptable. Although I cannot judge at this time to what extent the authors of this paper are right, I do think the Linear Trend View may have exaggerated the COVID-19 impact on baseline ozone. Further studies and discussions are definitely needed to come to a consensus. This paper could be a starting point for these. The paper is mostly well written. I have only a few minor points and recommend publication of this paper in ACP after revisions.

Specific comments:

- To be more robust and convincing, the 2-year average point with error bar for 2018 and the related monthly mean ozone values should be included in Figure 1. Some of the 2-year averages do show quite large deviations from the quadratic fit curve. In case a large deviation occurred in 2018, the extrapolation could be substantially impacted. In addition, it is not known why 2-year means are used in the regression. Can we obtain a significantly different fit using 1-year means? Will the conclusion also be different?
- The quadratic fit is obtained from selected datasets that are believed to represent baseline ozone, while the Linear Trend View does not pay much attention to the datasets selection. Therefore, it should be made clear that compared trends are based on same or similar (baseline ozone) datasets.
- Figure S2 is not cited in the main text and some related descriptions in Supplement seem to be unclear. For example, I do not understand why "t2=17" (line 65).
- Line 189: Clark et al. (2022) should be Clark et al. (2021).

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