We thank Dr. Cooper for his insights and constructive comments. Our response is as follows:

Specific Comments:

The goal of this analysis is to develop globally consistent maps of ozone production (these maps do not depict ozone loss, or net ozone production). The authors suggest on line 595 that the ozone production maps can be used to identify regions with high levels of ozone pollution, which seems perfectly reasonable. For example, they show that the regions of New York City, Los Angeles, San Francisco Bay area, and Lake Michigan have high levels of ozone production, and these same regions are well-known for persistent ozone pollution in the summer months. However, there are many other regions across the USA and Canada that have high ozone pollution levels, which don't seem to stand out on the map for July 2019. Perhaps this is due to just one month being shown, and perhaps other regions would stand out during other months, but without any evaluation, we don't know if this is the case. I think there is a good opportunity here to apply the ozone observations in the TOAR database to these ozone production maps to see if they do indeed capture the urban areas with the highest ozone pollution. For example, Figure S1b in the supplement to Fleming et al. (2018) (pasted below) shows the number of days per year that maximum daily 8-hour average ozone (MDA8) exceeds 70 ppb, across North America, Europe and East Asia, based on observed ozone from 2010 to 2014 (these data are from the TOAR database). A similar map could be made for July 2019 (or other months) to see if the observed ozone pollution hotspots coincide with the ozone production hot spots. The American Lung Association publishes an annual report (State of the Air) listing the urban areas in the USA with the highest ozone pollution. The most recent analysis, based on EPA ozone data for 2020-2022, lists the following urban areas with the highest ozone pollution (number of days per year when MDA8 ozone exceeds 70 ppb) (https://www.lung.org/research/sota/city-rankings/most-polluted-cities):

1. Los Angeles
2. Visalia (Central Valley)
3. Bakersfield (Central Valley)
4. Fresno (Central Valley)
5. Phoenix, AZ
6. Denver, CO
7. Sacramento (Central Valley)
8. San Diego

9. Salt Lake City, UT

10. Houston

11. Las Vegas

12. San Jose-San Francisco-Oakland

13. Dallas

14. NYC

15. El Paso, TX

16. Fort Collins, CO

17. Chicago

18. El Centro, CA

19. Reno, NV

20. Colorado Springs, CO

The 4 high ozone production regions in the USA identified by the authors are in this list of the top 20 polluted cities, but why don't the other 16 cities stand out on the ozone production map? Similarly, the Po Valley of northern Italy is the ozone hot spot for Europe, but the ozone production map gives the impression that Benelux would have higher ozone pollution levels.

Response

Ozone production rates are only one element among several physiochemical processes determining ozone concentration. All these elements can be categorized into:

Chemistry (ozone production rates) + vertical transport (advection + diffusion) + horizontal transport (advection + diffusion) + cloud chemistry + dry deposition + background values

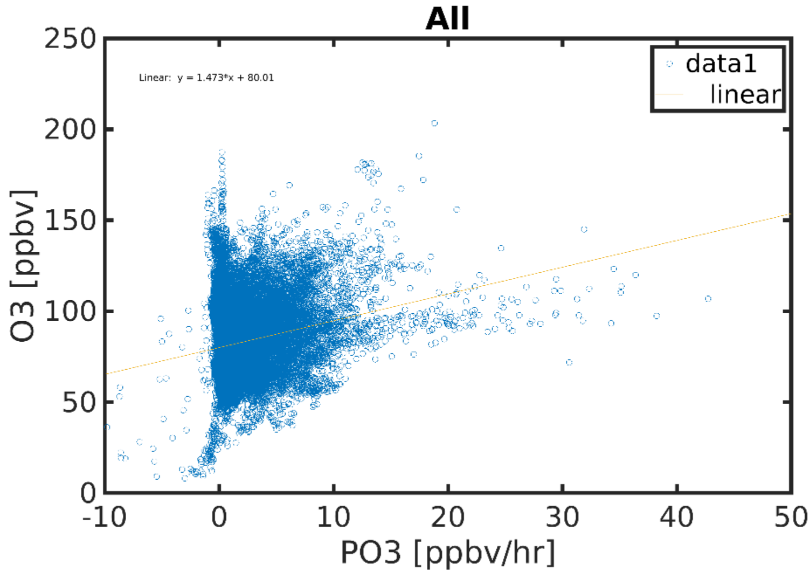
Of particular significance is the long lifetime of ozone (O_X~ 73 days), which, when combined with the increasing background ozone concentration by altitude, wields a significant influence on the transport effect. This influence is so pronounced that places like Denver, with their higher altitudes and thus more contribution of ozone through vertical diffusion and background ozone, do not need a significant amount of local ozone production rates to push surface ozone to an unhealthy level.

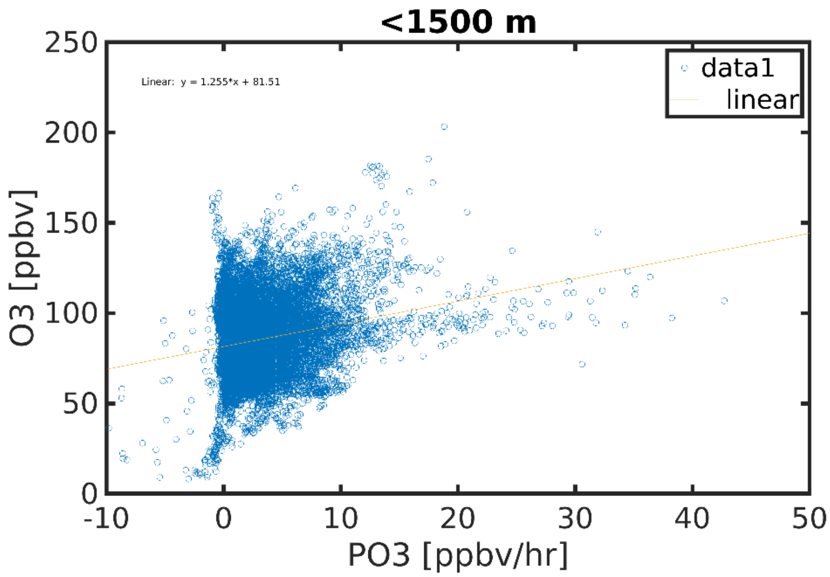
Some of these physiochemical processes can have conflicting signs requiring us to perform a full-chemistry modeling experiment. For instance, an expanded PBLH (thus more turbulence and less aerodynamic resistance) increases the contributions of high ozone aloft to the surface but simultaneously increases the dry deposition velocities over vegetated areas. Understanding how these conflicting contributors can cancel each other needs a model.

We observed a prime example of a decoupled relationship between ozone concentration and PO_3 in Souri et al. 2020 (https://www.sciencedirect.com/science/article/pii/S1352231020300820) over Seoul during a degraded air quality episode (June 9th, 2016). Figure 4 in that paper shows a high

concentration of HCHO and NO_2 over Olympic Park, leading to large PO_3 (also observed in Figure 8 in https://acp.copernicus.org/articles/19/5051/2019/acp-19-5051-2019.pdf). Despite accelerated PO_3, ozone concentration was substantially low compared to suburbs. This could result from various reasons, including larger dry deposition velocities over the park and lower aircraft altitude undergoing reduced background ozone + less ozone contribution through vertical diffusion.

Our research is backed by one of the most comprehensive and well-constrained box models in our deposit, giving us a strong foundation for our claim regarding the decoupled relationship between PO_3 and ozone levels. The following figures, which contrast PO_3 (x-axis) and ozone concentration (y-axis) during the KORUS-AQ campaign, including all altitudes and limited to <1500 m, provide clear evidence of a poor correlation (r<0.1) between them:





These figures suggest that a linear relationship between ozone concentration and PO_3 cannot be established; therefore, we should not expect high local PO_3 rates to strictly provide authoritative explanation of non-attainment regions.

While the decoupled relationship between ozone levels and PO_3 may appear to be a weakness for our product, we believe that it is a major strength. Due to convoluted physiochemical processes determining ozone concentration, one cannot easily attribute a trend in surface level to a specific contributor. It is because of this reason that we have to make several assumptions to rule out specific contributors (e.g., limiting observations to nighttime mountainous region) or to use various model experiments under various realizations. The advantage of our product lies in the fact that it provides a robust piece of information about the chemistry component largely influenced by local emissions. If one observes elevated surface ozone while moderate/low PO_3, our product signals the need for further investigation into other components.

We will eventually release the data for the period of 2005-2024 using OMI and TROPOMI to have a full picture of hotspots of PO_3. We do not wish to suggest that our product is sufficient to explain surface ozone variability. Therefore, we limit our response to this feedback by providing more caveats so as not to oversell the product.

Modifications

In Section 4.3.4. right after mentioning non-attainment region, we removed this part: "While it requires several physical processes, such as vertical and horizontal transport, to translate these PO_3 rates into ozone concentrations, applying this product in locating the hotspot of ozone polluters shows promise." And added:

"A robust relationship between PO_3 and ozone concentrations can only be established by factoring in physical processes such as horizontal and vertical transport, dry deposition rates, and background values. In regions with high background ozone concentrations, for example in mountainous areas, even a moderate level of PO_3 can elevate ozone concentration to unhealthy levels. Conversely, if there is a strong correlation between PO_3 and frequent ozone exceedances, such as those observed in the mentioned U.S. cities, it indicates that locally produced ozone through chemical reactions is the primary factor contributing to those events."

In the summary section, we added:

"It is important to recognize that PO_3 maps are just one piece of the puzzle when it comes to determining ozone concentrations. Several studies have indicated that accurately representing surface ozone is challenging due to difficulties in representing background ozone, vertical transport, and dry deposition rates (e.g., Zhang et al., 2023; Clifton et al., 2020). Therefore, we advise against directly linking high PO_3 rates from our product to increased unhealthy ozone exposure. However, our product can provide indications as to whether heightened ozone concentrations are associated with rapid local chemistry as opposed to other processes (e.g., meteorology or dry deposition rates). Further investigation using additional tools/data is necessary to gather a full picture of these processes."

Minor Comments:

In the first paragraph the authors make some general statements about the importance of ozone for health, vegetation and climate, but provide no references. This would be a good opportunity to cite the findings from the first phase of TOAR in three key publications, TOAR-Health (Fleming et al., 2018), TOAR-Vegetation (Mills et al., 2018) and TOAR-Climate (Gaudel et al., 2018).

Thanks, we now have included them.

Response
Thanks, we now have included them.
Modifications
Ozone not only poses significant risks to human health (Fleming et al., 2018) and agricultural productivity (Mills et al., 2018) but also influences the radiation budget, thereby affecting the climate (Gaudel et al., 2018).

Line 199 SZA is first mentioned here, but it needs to be defined

Response
Added.
Modifications
… solar zenith angle (SZA)…

Line 679 “This data has” should be “These data have”

Response
Corrected.
Modifications
These data have indeed …