RC1: <u>'Comment on egusphere-2024-720'</u>, Anonymous Referee #1, 18 Apr 2024, **Citation**:

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This is a very detailed paper using a large amount of satellite, ozonesonde and modelling data to investigate the precursor drivers to the trends in total column tropospheric ozone between 2005-2019 on regional and global scales. The use of NO_2, VOC, HCHO tropospheric column data is novel for this type of analysis, is within the scope of ACP and should be published subject to a slight restructure and few minor corrections.

We thank the reviewer for his comments and recommendations. Our responses are in blue following each comment.

General comments

It is unclear to me the relevance of the model analysis for different parts of the troposphere (Figure 5) if it isn't referred to in the later interpretation of the measurements or in the conclusion.

The simulated tropospheric ozone and its precursors in the lower, middle and higher troposphere are now mentioned in the discussion (e.g., secs. 3.3, and 3.43) and in the conclusion.

There is some clear parallel in the model analysis where the contribution and trends are separated by region (Figure 11) but can this be brought into the discussion more and perhaps section 3,3. (and Figure 5,11) be moved to after the measurements are presented (3.4.4, 3.4.5, 3.4.6, 3.4.7). A summary could then also include a discussion about which parts of the column are driving the trends in different regions of the globe, otherwise why include the model information?

We thank the reviewer for this comment. We have added this discussion to the conclusions as suggested. Figures 5 show the simulated mean partial column of tropospheric O3, CO, NO2, and HCHO and we believe it is suitable here in section 3.3 which addresses the model simulation. Figure 11 is located in section 3.4.3 for regional trends and likewise is suitable there since it addresses trends for several regions and latitudinal bands. We have included now a discussion in the conclusion regarding which parts of the columns are driving the trends.

Are the model trends inline with the measurements? Please include some reference to the model findings in the precursor measurement discussions and conclusions.

Comparisons to measurements are already in the text, for example, in section 3.4.3, as stated "Simulated TrC-O$_3$ trends are also quite comparable to those observed by OMI/MLS within the measurement model uncertainty (see **Error! Reference source not found.** and **Error! Reference source not found.**). Over Australia, the OMI/MLS trend of 1.05 DU/decade is higher than the model trend of about 0.2 DU/decade (see **Error! Reference source not found.**). However, since OMI/MLS trend has a calculated uncertainty (2σ) of 1.44 DU/decade, both the model and OMI/MLS for Australia are not statistically different."

We have also added related discussion to the conclusion.

The figures are a little confusing. It would make sense to use similar figures for each of the ozone precursors to allow easier interpretation. The discussion on CO trends includes more plots (including anomaly trend plots) for which the other precursor species there is a summary (also nice but maybe don't need both). Can the plots used be the same for all species in sections 3.4.4, 3.4.5, 3.4.6, 3.4.7, either anomaly time-series or summary of anomalies?

We have added new CO figures for the trend summaries, similar to NO2 and HCHO as the reviewer suggested.

As stated above Figure 5 perhaps relates more to the O$_3$ discussion and should sit with Figure 11 as they are related (contribution to each part of the column from model and actual trend). Also perhaps Figure 4 should sit later with Figure 12 (see later specific points).

As we mentioned earlier, Figure 5 presents the burdens of each precursor in while Figure 11 presents the trends for each region. We believe that Figure 5 sits in the correct place (sec. 3.3) following figure 4 that shows the burdens of all precursors globally. Figure 11 shows the simulated trends sitting in section 3.4 (tropospheric trends)

I think it is just a misunderstanding on my part but there should be a consistency with the time period that you are discussing, for the most part the time period 2005-2019 is shown but the main O_3 trend figure 6 is possibly until 2021. There is also some reference to COVID years and this seems a bit out of place in the paper unless related to the above point?

All figures are from 2005 to 2019 except for Figure 8b (2005-2021) which is shown only to demonstrate the effect of COVID-19. Figure 6 is also from 2005-2019 as shown on the legends on top of each panel. However, there was a typo in the caption that says 2004-2021, which is corrected now. We thank the reviewer for mentioning that typo.

Specific comments

Figure 2: Please include time range (2005-2019) in the figure caption.

Done!

Line 263: Use 'peroxyl' not 'proxy'.

Done!

Line 272: Self referencing, can you choose other references for these fundamental reactions?

Done!

Lines 281-282 and Figure 4: NO_2 column is stated to be decreasing in North America, Europe and Australia. Please include a reference for this relating to air pollution controls or alternatively Figure 4 should show the trend of NO_2 rather than the mean if you are referring to it? The trends are shown later in Figure 12 so discussion about them should be there unless you have another reference for it?

Done! A reference has been added.

Section 3.2, lines 290-295 generally needs more references when discussing sources from certain regions, not just 'e.g.' in brackets.

Done!

Figure 5: Model shows lower, middle, upper differences in precursor contribution. At this point the reader is interested in the trends within the column and whether any specific part of the troposphere has been increasing/decreasing over this time and in which regions, actually shown later in Figure 11. Can these be put together, perhaps in a later discussion?

Done!

Figure 6: What timescale are the trends over, 2005-2019 or 2005-2021?

Done! It is 2005-2019, the caption is corrected.

Figure 7: Does the right plot show the 'zonal mean trend' of column depths or should the caption say 'mean O_3' by latitude for different column depths for 2005-2019?

Done! The caption of the right panel has been further clarified "zonal mean of different column depths (right) from 2005-2019"

Figure 9: Can latitude of the observations be included on this plot?

Done! Table S 1 includes a list of the coordinates of ozonesonde stations used in the study. This is now mentioned in the caption as well.

Line 431: What is a partial column, is it defined?

The partial columns are labeled on Figure 11 as (lower, middle, and upper troposphere) in addition to the full troposphere. They are also defined in section 3.3: "lower (up to 700hPa), middle (700-400hPa), and upper (400hPa to tropopause) portions of the troposphere". We have further defined them in the text in section 3.4.3.

Line 547: Include reference for biomass burning activity

Done!

Figure 16: This is a nice figure showing average CO anomalies in column mean 2005-2021 but with trends only until 2019 which is good. Can we have similar plots for NO_2?

The trends are calculated only until 2019 so that it is consistent with other species and model simulations. As per the reviewer's earlier suggestion, we have included additional figures for Trend summaries similar to that of NO2 and HCHO.

Figure 18, Summary of trends, for HCHO, why don't we have this type of plot for CO?

As per the reviewer's earlier suggestion, we have included additional figures for Trend summaries similar to that of NO2 and HCHO. Figure 24: Monthly anomalies of HONO from soil by region, please include trend data on these.

Done. The figure is now updated with the trend values and their uncertainties.