Response to Reviewer 3 of Van Malderen et al. – 50 years of balloon-borne ozone profile measurements at Uccle, Belgium: short history, scientific relevance and achievements in understanding the vertical ozone distribution.

In this response, we included the reviewer comments in black. Specific comments are numbered. Our response are written in red, with the modifications in the manuscript in *red italic*.

This manuscript provides a detailed overview of the ozonesonde measurements Uccle. This is one of the most important and longest records of profiles measured at a higher frequency (3/week) than nearly all other global ozonesondes sites. The manuscript covers the ozonesonde history, editing techniques applied to past data (homogenization) and includes data analysis of long-term tropospheric and stratospheric ozone. The fully homogenized data is used in the linear regression and well-documented LOTUS models to evaluate trends. Trends are evaluated and compared to MOZAIC/IAGOS commercial aircraft profiles. An additional interesting topic is the evaluation showing an increase in the frequency of tropopause fold events observed in the ozonesonde record. The manuscript also discusses and documents the changes in manufacturer sonde models used over the long record and operating procedures (changes were minimal making homogenization of long-term data much more straightforward). It also presents an important documentation of the homogenization method used for their long term records. The manuscript presents satellite comparisons/validations with the Uccle ozonesonde database, one of the most critical applications of ozonesonde data. This manuscript is a substantial contribution that shows the importance of 50 years of ozonesonde data records.

Thank you very much for taking your time to review our manuscript and your positive feedback!

General Comment

1. Scientific Question: Figures S6 shows and example of a tropopause fold event - a narrow high ozone layer at 600 hPa. I am not all that familiar with tropopause folds but have seen some examples showing massive ozone in broad layers near the tropopause. The RH is very low in the green line (very hard to see the RH scale in light green) which would indicate stratospheric source but wondering if anything else that shows this is a purely stratospheric ozone peak?
   This is an example of a tropopause fold illustrating that stratospheric air can penetrate deeply in the troposphere, not only near the tropopause. The very low RH is one indicator of the stratospheric source, but the detection algorithm looks especially for tropopause folds which occur in connection to upper tropospheric frontogenesis in the polar jet stream region, as those are considered to be responsible for a large part of the mass exchange across the tropopause (see Van Haver et al., 1996, and references therein). During a test period, those authors used cross sections of potential vorticity from ECMWF analysis to check the necessary folding of the dynamical tropopause, resulting in the tuning of the stability, wind speed and vertical shear conditions as used in the detection method. We added to the figure caption that *"These criteria primarily focus on the detection of tropopause folds that occur in connection to upper tropospheric frontogenesis in the polar jet*

stream region, as those are considered to be responsible for a large part of the mass exchange across the tropopause (see Van Haver et al., 1996, and references therein).”
We must admit that at our printed out copies, we have no issue with the visibility of the light green color, which has also been used in other figures in the manuscript (e.g. Figs. 3, S1, S6). But, we will keep an eye on it.

Technical Corrections/Suggestions:

2. Line 43: First sentence states ozone is found mainly from surface to top of atmosphere (50km) which is true for all gases. Would be good to separate it out a little more and note that Ozone, O3, is a key trace gas in the Earth’s atmosphere, where is present in the troposphere but mainly resides in the lower to middle stratosphere (90%).
   Done, we added: *“with the highest concentrations in the lower to middle stratosphere (90% of total column ozone amount).”*

3. Line 109: I would say something like “funding limitations or reductions” here rather than“financial problems”
   Done, changed to *“funding reductions”.*

4. Line 151: reduction by 100% may sound like the ozone signal is zero, which can be the case in very high SO2 that exceeds ozone concentration. It would be more clear to state that – in particular, SO2 reduces the ECC cell response on a 1:1 basis for every SO2 molecule.
   You are right, we changed it to *“In particular, one SO_2 molecule cause a reverse current of two electrons, reducing the electrochemical cell response on a 1:1 basis”*

5. Line 170: Change “double soundings” to “dual soundings” so it matches with text in Figure 2.
   Done as suggested.

6. Line 208: Change “From 1990” to “Since 1990”
   Done as suggested.

7. Line 213: SECTION 4 Note: This section title is “Temporal evolution of vertical ozone concentrations at Uccle” but the section begins with “Total ozone trends from Dobson and Brewer”. Therefore, this section may be better titled as “Temporal evolution of total column and vertical ozone concentrations at Uccle”
   As a response to the other review report, we moved the “Total ozone trends” subsection to an appendix, so the title of Section 4 now better covers the entire contents of this section.

8. Line 227: “...on the Uccle total ozone concentrations pops up.” to “...shows in the significant dips in Uccle total ozone.”
   Done, changed to *“is shown in the significant dips in Uccle total ozone.”*

9. Line 231: “(e.g. the excess total ozone in 2010, the 2011 and 2016 low ozone anomalies).” to “(e.g. the excess total ozone in 2010, and the low ozone anomalies in 2011and 2016).”
   Done as suggested.

10. Line 351: Improve sentence to make clear if proxies were not used: “....,as there is no consensus on the used proxies to account for natural variability” which implies that

proxies were used or change to “....., as there is no consensus in using proxies to account for natural variability.”
Done, changed to “as there is no consensus in using (which) proxies to account for natural variability.”

11. Line 368: Need more clarity here: “(since 1995, but the post-2000 trends have the same magnitude)” Is a flat trend (zero slope) meant for same magnitude. Also, wondering if post-2000 trends are shown in one of the graphs.
You are right. We changed the text in “*The Uccle tropospheric ozone concentrations have been increasing at about the same rate since 1969 (in black in Fig. 3) as since 1995 (in green in Fig. 3), and also the post-2000 increase rate is very similar (not shown here, but could to some extent be noted from the tropospheric ozone column time series shown in Fig. S7).*”

12. Line 621: Replace...” is almost entirely compensated by the gain” with...” has nearly fully recovered by the +2%/decade gain between 1997-2019”
Done as suggested.

13. Line 645: The most recent update by Stauffer shows the ozonesonde drop-off in TCO ranges from 3-7% was observed at 13 of 53 global stations (25%) 1/4 rather than 1/3.
Yes, thank you, we are aware of this update (being member of the ECC Drop-off Task Team within ASOPOS) and even a more recent one (after re-processing of two Canadian sites). We added to the text: *“a number now reduced to about 20% (12 of 60 global stations, Stauffer et al., 2021, private communication)”.*

14. Line 651: The drop-off was mentioned in line 645 – suggest removing “, as the total column ozone drop-off in a third of the ozonesonde stations (Stauffer et al., 2020) paper made obvious”
Done as suggested.