Response to RC 2

Thank you very much for a concise and most useful review. It has helped us re-focus on the key points and hopefully made it easier for the reader.

We have made adjustments or added material in response to almost all your comments. The quoted changes listed below were our original fixes. After incorporating changes in response to the other ACP reviewer and an independent reviewer, a final read-through has resulted in a number of editorial fixes and so the quotes below may be slightly different (but not in content). The additional review asked for the N2O budget tables (which come directly from these calculations) and so a short paragraph and supplemental table was added at the end.

> RC2
>
> This is a concise, generally well-presented analysis of the changing N2O stratospheric sink and lifetime. I appreciated the brevity but also think some of the sections could be expanded a bit to improve clarity. The analysis has interesting and important implications, including for climate change-driven changes in the BDC and for the clearance of ozone-depleting substances from the stratosphere. I recommend publication with some minor revisions.

Thank you, and thanks for the most helpful suggestions.

> Abstract
>
> The second sentence repeats part of the first sentence and is also a bit awkward, since “it” has no clear singular antecedent. Perhaps rewrite as,
>
> "This [DECREASE] is occurring because the N2O abundances in the middle tropical stratosphere, where N2O is photochemically destroyed, ARE increasING at a faster rate than the bulk N2O in the lower atmosphere."

Thank you, great sentence. It is adopted with minor edits noted above.

> The result that the N2O lifetime is decreasing, even despite the reduced photolysis coefficient in the upper stratosphere due to ozone recovery, seems like an important concept to include in the abstract, since it lends further support to the importance of the increased BDC in driving the decline in N2O lifetime.

We tried adding a clause to the following sentence like: *"Because the chemical loss frequency of N2O in the critical region is decreasing,"* But after the read-through of the clean text, it sounded clumsy and we deleted it.

> The projection to 2100 is quantitative (20% increase) but somewhat speculative, while only a qualitative statement is made about the 2005-2021 trend, even though the calculations over that period are solidly grounded in data. It might be better to include a quantitative estimate of the 2005-2021 trend.

We have added the rate of decrease (-2.1 ±1.2 %/decade) to the first sentence. Good point.

> Line 15, I would suggest removing “but relatively minor” since it seems to belittle the findings of this paper and also is not really developed in the body of the manuscript. In general, I think a stronger concluding sentence, which sums up the important implications of this work, would serve the Abstract better.

OK, removed the qualifier, but could not come up with a stronger concluding sentence.

Other comments

Line 26, “but these observations run counter to the climate model projections (Karpechko et al., 2018; Abalos et al., 2021; Garney et al., 2022)” Can the authors spell out more clearly what the observations are showing for those less familiar with this literature, e.g., are the SF6 observations suggesting no change in the BDC, or are they showing a slower BDC?

Yes, that was obscure. We changed it based on RC1 to *"While models predict an enhanced BDC, the SF6 observations indicate an unchanged or decreasing BDC, but with large uncertainty (…refs"*

Line 59, space => spaced

Done.

Line 63, should the second 86 be 84? Otherwise, it doesn’t make sense that the dataset extends from 84N to 84S.

This section on data set latitudes was confusing and has been rewritten in this paragraph and the next.

Lines 87-94, This argument for the minimal impact of the solar cycle impact might belong in the Results/Discussion rather than the Methods, e.g., grouped together with discussion of other uncertainties like calibration drifts.

Good idea, we moved it to the end of Section 3.

Line 101, please clarify which source files have changed.

P2015 used the GOZCARDS data, 5 degree latitude bins. (noted)

Line 170, Please include a summary statement to wrap up this paragraph. As currently written, the impact of possible calibration drifts is not clear. Since the conclusions of this paper depend in large part on the relative trends in N2O in the middle/upper stratosphere vs. lower in the atmosphere, it seems important to leave the reader with a clear statement.

Good idea. We added: *"Thus, any calibration drift that impacts the lifetime (i.e., occurring in the critical region 3 to 30 hPa and 30°S to 30°N) is negligible compared to the increasing trend in N_2O loss (+5.0 %/decade), or it is slightly negative, which if corrected would further increase the trend."*

Line 204, proportion => proportionally

Done.

Paragraph starting at line 201, This is an interesting side note. Would this change be detected in a decrease in the NOy/N2O tracer correlation slope in the lower stratosphere? e.g., as discussed in Nevison et al. (1999), GBC, 13, 737-742.

Very interesting. We added this thought and reference to the section. Further, we added a brief summary of the overlapping work on the MLS trends in N2O by Strahan that was co submitted and just appeared in GRL. We have added a short paragraph highlighting that study and its overlap with ours.

Strahan, S. E., Coy, L., Douglass, A. R., & Damon, M. R. (2022). Faster tropical upper stratospheric upwelling drives changes in ozone chemistry. Geophysical Research Letters, 49, e2022GL101075. https://doi.org/10.1029/2022GL101075.