Reply to Reviewer 1

Please note that the reviewer's comments are included in normal font and our responses are in italics below.

<u>General Comments</u>

This manuscript presents an inversion study of five HFCs (different combinations of three at a time) to infer global annual mean hydroxyl radical (OH) concentrations using a 12-box model. The inferred OH anomalies are compared against other estimates from past MCF and CTM-based analyses. Finally, the impact of the optimized OH on the growth rate and emissions of CH_4 is derived from the same 12-box inversion relative to a Spivakovsky et al. climatology. The results suggest that variability in the annual OH anomaly is less than 2% with no trend over the period 2004-2021, that OH abundance in year 2020 was likely low but not significantly lower than in prior years (2018 especially), and that CH_4 emissions using the optimized OH had a smaller increase than is inferred using climatology, though the difference is small.

Overall, this is a compelling study focused on an important topic. The global oxidizing capacity is a subject of much debate, and further observational constraints to quantify it are always needed. The methodology used is sound, and I see no shortcomings in what is presented. I point out in my comments an opportunity for expanded discussion and a couple small clarifications, but otherwise, I think the article is well-presented, is of interest to readers of ACP, and represents a significant advance beyond the use of MCF as the main observational proxy of OH.

We thank the reviewer for the positive feedback and reply to the specific comments below.

<u>Specific Comments</u>

L39: Turner et al., PNAS, 2017 (https://doi.org/10.1073/pnas.1616020114) could be added to the list of MCF studies

We agree and have added Turner et al. to the list of MCF studies.

L275: It would be informative to expand on the discussion of the "shortest lived species" a bit. It is stated earlier in the manuscript that the derived OH may be more sensitive to the shorter-lived species in the inversion. Wouldn't it also make sense that, in the actual atmosphere, the shorter-lived species would adjust more quickly to either changes in emissions or variations in OH? This is not explicitly stated in the text, but since the authors separated out inversions that included the shorter-lived species (e.g., in Fig. 3), why not discuss the implications more?

We agree that the discussion on the results using the shorter-lived species should be expanded considering the difference between the OH estimates using HFC-32 and HFC-152a (the shorter-lived species) and the other estimates. We have added some explanation to the last paragraph of section 3.3, where this difference in results is first mentioned. It is true that *the concentration of a shorter-lived species will have a stronger response to a change in OH. However, this species will be less sensitive to a change in emissions due to the greater loss rate.*

Figure S1: For the lower row of panels in each set, I think it would help to indicate on the y-axis that this represents a difference (something like "HFC-32 Difference, AGAGE – NOAA (ppt)" or similar).

We have added "Δ" to the y-axis labels to indicate that this is a difference.

<u>Technical Corrections</u>

Figure S5: Should the caption state "ten inversions" rather than six?

No, the caption is correct, although there are 10 inversions in total, each species is included in only a sub-set of 6 inversions. There are 10 possible ways of selecting 3 species from a set of 5, so some species are excluded in some inversions.

Figure S6: Figure seems low resolution, e.g. when compared to Figure S5.

We think this is a rendering issue of the pdf file, which may be related to the fact that Fig.S5 contains transparency (i.e., the grey uncertainty envelope). The original jpg has the same resolution as the other figures.