Response to Reviewers for "*Characterizing variability and vertical structure of water vapor in the extratropical lower stratosphere*" by Emily Tinney, William Randel, and Jun Zhang

We thank the reviewers for the overall positive comments on the manuscript and the useful suggestions for improvements. We have addressed all the reviewer comments and include individual replies below (line numbers refer to the revised manuscript).

Reviewer comments are shown in **black** and our responses are given in **blue**.

Reviewer 1

I thank the authors for their careful and thorough revisions. The manuscript has been substantially improved, and my previous comments have been well addressed. I am happy to recommend acceptance, with only two minor comments on the newly added text. These can be addressed during final revision and should not delay acceptance.

We thank you for these kind comments and suggestions!

Line 247: The discussion of the weak interhemispheric correlation in O_3 anomalies is interesting. Could the contrast with H_2O be explained by their different vertical gradients? As shown in the response, the strong vertical O_3 gradient from about 2 to 7 km above the tropopause makes its variability more sensitive to hemispherically independent extratropical downwelling, whereas H_2O vertical gradients in these level are small and its variability is more strongly influenced by the shared tropical cold-point entry signal. If this interpretation is correct, a brief explanatory sentence would help clarify why the two species show different correlation structures.

Thank you for this suggestion! We have added a sentence to the effect of this in Lines 245-247

Line 302: I suggest limiting the statement "these differences question the reality of the MLS trend results" to the relevant region, for example: "…these differences question the reality of the MLS trend results in the troposphere and ExTL."

Done

Editor

P3, L82: verification? Do you mean validation?

Thank you for catching this, this has been changed.

P6, L145: Parentheses around the Hegglin et al. (2009) reference are obsolete.

Done

P6, L155: antarctic -> Antarctic

Done

Fig 3: Grey areas iin ACE data? Are these missing data or excluded data? This should be explained in the figure caption.

Done

References to supplementary figures: Just write Fig. S1, Fig S2 .....without writing additionally in Supplementary Material.

Done

I do not really agree with the last sentence of the Summary and Discussion. Why should this be a cause of a retrieval artifact? Is this a known problem of the MLS v5 data? There have been several H2O trend studies been published using earlier versions of the MLS data. Have these encountered similar inconsistencies? Couldn't there also be uncertainties from the data analyses performed and/or methods used? I would appreciate here a discussion of all possibilities. Additionally, I would like to ask you to have a look at the ACP guidelines for the title, abstract and concluding section: https://www.atmospheric-chemistry-and-physics.net/policies/guidelines_for_authors.html . I am fine with the title and abstract of your manuscript (although these also may be improved), but the conclusions are definitely missing. What are the caveats and limitations of your study? What are the implications? What does thtes results mean for our understanding of the state and/or behaviour of the atmosphere and climate?

Thank you for this comment. We have changed the original final sentence and added paragraphs of discussion of the limitations and implications of this work in Lines 350 - 370. Overall, we believe that our results and discussion throughout the paper support the idea that there could be an issue in the MLS data that results in this negative trend. However, we do agree that our original final sentence may have been too strong based on uncertainties and limitations. We hope that our added discussion helps to address this.