Review of "Climatology, sources, and transport characteristics of observed water vapor extrema in the lower stratosphere," Tinney and Homeyer (2023)

General comments:

The study authored by Tinney and Homeyer presents an interesting and significant analysis of the contributions of water vapor extrema located within the lowermost stratosphere. In the context of extensive prior work examining stratospheric water vapor extrema that relied upon a more conservative criterion, the authors advance an argument that such a strict criterion provided an incomplete understanding of water vapor extrema and that a more nuanced approach to stratospheric water vapor extrema is necessary. The analytical framework and dataset used are appropriate for the scientific questions addressed, and the results support their argument. However, given that the crux of the study rests upon accurately parsing lowermost stratospheric observations from tropospheric, additional description of and support for the methodology presented is needed.

Specific comments:

1. As accurately identifying MLS levels that fall within the lowermost stratosphere is critical to the analysis, and the authors have developed an extensive set of filtering criteria, additional details about how these criteria were selected would strengthen the argument. Specifically, explicit details about the rigorous testing and evaluation mentioned in line 103 are needed. Additionally, how sensitive are the results of your analysis to these criteria?
2. Does the absolute threshold of 8 ppmv for identifying water vapor extrema introduce geographic or seasonal biases due to differences in background concentrations that fluctuate?
3. Given the importance of tropopause height to this analysis, are any complications introduced by the use of ERA-5 tropopause height for the GPM data while MERRA-2 tropopause heights are used with the MLS data?
4. Why are annual cycle analyses for the other regions identified in section 3.1 not included?
5. The "Conclusions" section needs a brief discussion of the limitations associated with the assumptions of the study design, and with the various proxies (e.g. 60% of prior 5 days spent in the troposphere as large-scale TST) used.

Technical corrections:

Line 22 – "essential to improve understanding" OR "essential for improving our understanding"

Line 24 – this sentence is a bit convoluted and may benefit from being split in two

Line 25 – authors may consider including discussion of water vapor climate feedbacks (e.g. Banerjee et al., 2019; Konopka et al., 2022; Nowack et al., 2023)

Line 27 – theta has not been introduced as potential temperature

Line 30 – is it important to specify how deep into the stratospheric overworld you are defining the 'total LS?'

Line 33 – ~~alternatively~~ additionally

Line 46 – extreme LOCALIZED stratospheric hydration

Line 48 – Clapp et al. 2019 and Liu et al. 2020 also support this

Line 168 – ~~alternatively~~ in contrast

Line 169 – no source according to what?

Line 175 – provide statistics of number of layers and profiles included that would have been excluded using prior criteria

Figure 3 – define tropopause break

Line 212 – what sort of timing of convection and timing of mixing is necessary to create hotspots in the Fig 1 distribution instead of a latitude band smear in the context of zonal flow?

Line 215 – Clapp et al. (2021) discuss significant outflow from the North American Monsoon Anticyclone to the west in this region consistent with the authors' results

Figure 6 – why the 20-profile threshold?

Line 270 – 100 hPa previously defined as stratospheric overworld earlier in the introduction

Line 279 – why is the US the dominant contributor? From the figure it appears equal in magnitude to the stereotypical Southwest US/Mexico NAM region. What contributes to the September and October period?

Line 284 – is this not due to differences in tropopause heights associated with the different monsoons?

Line 290 – why the peak in December/January for AMA and NAMA?

Line 297 – note the percentages as percentages of total MLS observations

Line 299 – "the analysis"

Line 305 – was this not the case for the SC region?

Line 307 – does monsoon circulation not include a meridional component?

Line 309 – reiterate how this study defines relationship to large-scale TST

References:

Banerjee, A., Chiodo, G., Previdi, M., Ponater, M., Conley, A.J. and Polvani, L.M., 2019. Stratospheric water vapor: an important climate feedback. *Climate Dynamics*, *53*, pp.1697-1710.

Clapp, C.E., Smith, J.B., Bedka, K.M. and Anderson, J.G., 2019. Identifying source regions and the distribution of cross-tropopause convective outflow over North America during the warm season. *Journal of Geophysical Research: Atmospheres*, *124*(24), pp.13750-13762.

Clapp, C.E., Smith, J.B., Bedka, K.M. and Anderson, J.G., 2021. Identifying Outflow Regions of North American Monsoon Anticyclone-Mediated Meridional Transport of Convectively Influenced Air Masses in the Lower Stratosphere. *Journal of Geophysical Research: Atmospheres*, *126*(10), p.e2021JD034644.

Konopka, P., Tao, M., Ploeger, F., Hurst, D.F., Santee, M.L., Wright, J.S. and Riese, M., 2022. Stratospheric moistening after 2000. *Geophysical Research Letters*, *49*(8), p.e2021GL097609.

Liu, N., Liu, C. and Hayden, L., 2020. Climatology and detection of overshooting convection from 4 years of GPM precipitation radar and passive microwave observations. *Journal of Geophysical Research: Atmospheres*, *125*(7), p.e2019JD032003.

Nowack, P., Ceppi, P., Davis, S.M., Chiodo, G., Ball, W., Diallo, M.A., Hassler, B., Jia, Y., Keeble, J. and Joshi, M., 2023. Response of stratospheric water vapour to warming constrained by satellite observations. *Nature Geoscience*, pp.1-7.