Reply to reviewer 3

The paper presents an intercomparison of stratospheric water vapor as produced by the Lagrangian transport model CLaMS driven by meteorological winds and temperature from three modern reanalyses. The results are compared with SWOOSH and MLS observations. In addition to comparing the magnitude of the entry values, which are dependent on the tropical tropopause temperature in each reanalysis, the annual cycle, QBO, ENSO and volcanic signals are compared, as well as the linear trends. The results are accurately presented and the paper is well written. I recommend publication after the following minor issues are corrected.

We are grateful for reviewer3's suggestions, which are very helpful to improve this work. The changes corresponding to the comments can be tracked by the text in orange in the manuscript. The responses or clarifications are specified following each suggestion below.

- Page 1 Line 15: cloud effect

Corrected to 'long-wave cloud radiative effect'.

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- Page 6 Line 19: here and in other parts of the paper: the QBO is not a periodic signal, please correct 'periodic' by 'quasi-periodic'.

Corrected throughout the paper.

- Section 2.3: The authors are confusing the SAO signal, which is present in the upper stratosphere, with a semi-annual harmonic component of the annual cycle. The terminology 'SAO' should only refer to the former.

We agree. This point was also made by Reviewer 1. The usages of 'SAO' are corrected to semi-annual harmonic (SAH).

- Page 7 Line 7: 'variation' should be 'variance'

Corrected.

- Page 11 Line 8: ‘tropical tropopause temperatures’: are these Lagrangian cold point temperatures? Please specify.

No, they are not the Lagrangian cold point. Here tropical tropopause temperatures refer to the minimum of tropical mean (averaged over 20S-20N) temperature between θ=360K and 420K. The caption is revised accordingly.

- Page 12 Line 17: In addition to tropical upwelling, Glanville and Birner (2017, ACP) argue that mixing effects could be important for the tape recorder. This relevant information could be included here, as it implies that not all differences in the tape recorder signal should be attributed to tropical upwelling.

Thanks for the remark, which is indeed relevant. The information is added with the reference at Page 13 line 2-3.

- Page 14 Line 12: ’Although we use different methods to estimate the AC amplitude’: Why are different methods used and which method is used here?

In section 4.1, we simply used climatological monthly mean to represent AC as shown in Figure 6. The phase propagation is determined by strongest correlation for each layer to the layer below. In section 4.2 (original Fig. 7 and 8; new Fig.7 in the revised version), the harmonic regression with a sine and cosine term is used to determine the amplitude and phase of AC.

- Page 15 Line 5-6: can you point to specific ‘small-scale processes that must be parameterized in the model’?

More explicitly, that means the choice of mixing parameter (or mixing strength) in the model (which describes the small-scale processes in reality) might be of importance in the modelling of water vapor in the Southern Hemisphere subtropical lower stratosphere.

- Figures 8 and 10: I do not understand the meaning of the arrows, please explain more clearly.

The arrows show the primary regions where the phase differs from the benchmark phase (referring to the leftmost panel in each row). Upward arrows show phases that *lag behind the benchmark phase while downward arrows show phases that lead the benchmark phase.*

- Page 16 Line 9: quasi-periodic

Corrected.

- Section 5 (Figure 10): it would be much easier for the reader if you describe the interpretation of the QBO phase representation in Fig. 10 here, instead of having to go back and look for the information.

Agree. We now combined the two figures as the new Figure 8 for QBO and did the same for AC (new figure 7).

- Figure 11 caption: Please remind the reader that these are values at 400 K.

The information is added to the caption of Figure 9 in revised manuscript.

- Page 20 Line 21: Why is the lag for the ENSO signal on H2O entry anomalies so long? One year seems an excessive time lag, since the signal in tropical upwelling maximizes only after a few months.

The lag for ENSO from our regression is 10-11 months. There are two reasons for the long lag time:

1) *The lag time is location-dependent. When considering the zonally resolved lag time distribution for AoA at 17km to ENSO, the response time is mostly below 4 months. However, the tropical mean data we used shows lag time around 10-11 months. One potential reason is the effect of smoothing of localized signals.*

2) *Note that we used H2O at 400 K isentrope. The propagation from cold point tropopause to 400K typically takes 1-2 months.*

- Page 21 Line 5: since this result is not shown in Table I, I recommend adding ‘(not shown)’

Added.

- Page 25 Line 33: remove ‘relatively’

Removed.

- Page 27 Line 8: typo ‘n ext’

Corrected.