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Comment on acp-2021-647

Anonymous Referee #1

Referee comment on "Enhanced upward motion through the troposphere over the tropical western Pacific and its implications for the transport of trace gases from the troposphere to the stratosphere" by Kai Qie et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-647-RC1>, 2021

This is an interesting and useful study. However the scientific content, the quality of the study and its presentation should be improved. In particular, the text is in some parts very descriptive and technical. I suggest some major revisions before publication by ACP.

General comments:

1) In general in the manuscript it is very often written 'we found a positive or negative trend'. Please specify here your message by adding some numbers in the text (a trend of xxx per year or a change of xxx within 60 years from 1958 to 2017). It would be also very helpful to give the reader an impression whether this trends are of minor or major importance by adding some numbers from the literature for comparison. In general, I am wondering that the results are not discussed more quantitatively (see specific comments below). Further, please explain in detail how the trends are calculated and how the El Niño Southern Oscillation (ENSO) is considered in calculating the trends.

2) Figures: In general, the font size of the labels is very small and should be enlarged. Further, the text in the figure captions is very similar to each other. Please give here the reader more information which data or model simulations are shown and add some explanation what is important or what is the main message of the figure.

3) In Section 2 the used data sets and model simulations are described. However I am missing a bit more motivation for the reader to understand why these data sets and model simulations are used. A bit more explanation would be helpful.

3) The use of observations such as CO satellite measurements would strengthen the main

message of the manuscript. Therefore I recommend to add some satellite data (e.g. MLS CO <https://mls.jpl.nasa.gov/eos-aura-mls/data-products/co>)

Specific Comments:

P2 L2: 'A significantly intensified upward motion through the troposphere over the TWP in the boreal wintertime (November to March of the next year) has been detected..' Please make this statement more quantitative.

P2 L18: Please specify here which reanalyses are used.

P2 L23: 'numerical simulation' --> 'simulation with WACCM4' ?

P2 L24: 'show that more CO could be elevated to the tropical tropopause layer (TTL)' Please make this statement more quantitative.

P2 L27: Why is aerosol explicitly emphasized here. Please clarify (e.g. outflow from polluted air from South Asia?)

P3 L42: Please add possible sources of ozone-depleting halogen-containing substances in TWP (outflow from anthropogenic emissions from South Asia, natural maritime bromine-containing substances, .. ?).

P4 L45: (Saiz-Lopez and von Glasow, 2012; Wang et al., 2015). -> (e.g. Saiz-Lopez ...).

P4 L46: 'the coldest tropopause' of what? Please specify.

P4 L49: 'an important region for troposphere-to-stratosphere transport' Please add some references.

P4 L50: Is the TWP more important for stratospheric chemistry as other regions in the atmosphere? Please clarify?

P4 L66-70: The impact of ozone-depleting halogen-containing substances is already mentioned on P3 L42. I propose to combine these two sentences in one paragraph.

P4 L71: 'Based on a trajectory model, Fueglistaler et al. (2004) pointed out that the TWP region is a primary source of the tropospheric air entering the stratosphere and approximately 80% of the trajectories ascending into the stratosphere enter the TTL from the TWP'. However in L63 it is written: 'the TWP is not the dominant entry of trace gases transported from the troposphere into the lower stratosphere'. Please rephrase this statement more carefully.

P6 L100: 'using reanalysis datasets and model simulations' --> 'using JRA55, ERA5 and MERRA2 reanalysis and different WACCAM4 simulations as described in Sect. 2.'

P6 L102: 'is also discussed.' --> ' will be discussed in Sect. 3'

P6 L110: Please add the horizontal resolution of ERA5 data ($0.3^\circ \times 0.3^\circ$), which is much higher as in JRA55 and MERRA2. What about differences in vertical and temporal resolution. Please specify.

P6 L124: 'UTLS' is not yet introduced in the text.

P6 L125: 'even though there are still large biases in the reanalysis datasets' What are the differences between the three different reanalyses (JRA55, ERA5 and MERRA2) used here? Please specify.

P8 L145: 'except that the global SSTs are fixed to the climatological mean values during 1955-2018 (long-term mean for each calendar month during 1955-2018.' Why are the SST not fixed to a value representative for the beginning of the 60-year period?

P8 L146 Please explain the added-value of a time-slice experiment compared to the hindcast simulation.

P8 L150: For better motivation, please explain in more detail why this set up is used for the two time-slice simulations.

P9 L171: 'the climatological distribution of the vertical velocity at 150 hPa for each month of the year.' --> Mean values of the vertical velocity at 150 hPa for each month averaged over 60 years from 1958 to 2017. Yes?

Why is JRA55 and not ERA5 or MERRA2 selected for Fig.1? What are the differences between JRA55 and ERA5/MERRA2?

P9 L180: please add text within ++: 'which is more important to the transport of air over the TWP from the lower troposphere to the TTL +compared to the summer months (as shown in Fig. 1) + and subsequently to the lower stratosphere.'

P9 L182: 'Notably, the 150 hPa w shows no subsidence over the maritime continent, while there is descending motion over the maritime continent at 100 hPa (not shown), which is referred to the "stratospheric drain" (Gettleman et al., 2000; Sherwood, 2000).' The 100 hPa values should be shown in an electronic supplement.

P10 L186: Please explain in detail how the trend is calculated.

P10 L187: 'using reanalysis datasets' -> 'using JARA55, ERA5 and MERRA2 reanalyses.'

P10 L191: ->'is intensifying through the troposphere from 1958 to 2017.'

P10 L193 : add 'used here' or 'used in this study'

Figure 2: In MERRA2 the horizontal winds seem to be much stronger compared to JARA55 and ERA5. Could you make a comment on this. Please discuss the similarities and differences of the three reanalyses in more detail. Maybe you could show an additional figure showing the differences of ERA5 and MERRA2 compared to JARA55. ERA5 has much higher spatial and temporal resolution as JARA55 and MERRA2, therefore I would expect pronounced differences to JARA55 and MERRA2, in particular convection is much improved compared to the previous ECMWF reanalysis ERA-Interim.

Figure 3: Please Explain how 'standardized intensity' is calculated.

What is the reason for the extreme minima (1981, 1991, 1999)? El Niño Southern Oscillation (ENSO)?

P10 L201: 'This suggests a comprehensive enhancement of vertical velocity though the whole troposphere, which is evident from the surface to 100 hPa (not shown).' Figures demonstrating this could be shown in an electronic supplement.

P10 L205: 'Due to the data limitation, it is not possible to show the corresponding changes of trace gases by observations.' I agree that it is difficult to find observation from 1958 to 2017. However satellite measurements from shorter time period could be used (e.g. MLS CO available since August 2004; <https://mls.jpl.nasa.gov>).

P11 L210: 'of observed OLR' --> 'of observed OLR provided by NOAA (see Sect. 2)'

P11 L222: 'CPTT' is not yet introduced. Fig. 4b is not referred to in the text --> '.. the cold-point tropopause temperature (CPTT; see Fig. 4b) shows significantly decreasing trends over the TWP in NDJFM during 1958-2017,... However negative trends are also found in other regions in low and mid-altitudes, except in the Pacific.'

P12 L242: 'The SSTs over the TWP are positively correlated with the upward motion intensity over the TWP, while the SSTs over tropical central, eastern Pacific, and Indian Ocean show negative correlations.' I am wondering that the positive correlation pattern is somewhat shifted to the east, then the western part of the maritime continent (100°E-120°E) is also negative correlated. However, in the western part of the maritime continent (100°E-120°E) the trends of horizontal winds (Fig. 2) are large. Maybe, it is useful to avoid misunderstandings to mark the region of the TWP somehow (e.g. by a box).

P13 L253: 'a couple of model simulations' --> 'a couple of model simulations with WACCAM4'

P14 L277: 'a couple of time-slice runs (R1 and R2) are performed (more details are given in the section 2).'

--> It is maybe a matter of taste, but I would prefer in general to say 'simulations instead of 'run'. Please repeat the main features of R1 and R2 as a reminder for the reader.

P14 L289: 'The changes in the OLR' --> 'The changes in the OLR simulated in WACCAM4'

P15 L300: 'We now discuss about the relationship between the trends of the upward motion over the TWP and the changes of the trace gases in the lower stratosphere.' -->

'The relationship between the trends of the upward motion over the TWP and the change of CO and water vapor in the lower stratosphere simulated with WACCAM4 will be analyzed. It is expected, that a positive trend in the upward motion over the TWP yield higher CO in the lower stratosphere caused be enhanced vertical upward transport. However, water vapor mixing ratios in the lower stratosphere depends in addition from the temperature in the UTLS' Is that what you would like to discuss here ?

Section 3.3 is written somewhat confusing, therefore I propose to write a short introduction of Sect. 3.3 summarizing previous results from the literature and subsequent the new results of Qie et al.

P15 L303: 'in different simulations are displayed' --> 'are shown based on the Control and the Fixsst simulation as well as using their difference..'

P15 L303: --> 'in Fig. 7d-i'

P16 L328: 'As mentioned above in section 3.1, the observed tracer gases (e.g., CO) have very limited data record and may be affected by a mixture of anthropogenic and natural (e.g., biomass burning) emissions and the ENSO events (e.g., Duncan et al., 2007; Logan et al., 2008). It is therefore very hard to identify the relative contribution of single factors.' This sentence is here not very helpful, please remove it.

P16 L332: 'We utilize the numeric simulations' --> 'We use the Control and the Fixsst simulation with WACCAM4 ..'

P17 L344: 'increasing trends over the TWP' How much is the increase in CO within 60 years? Please add some numbers in the text. ($4 \cdot 10^{-4}$ ppm per year -> 0.024 ppm change in CO in 60 years; that seems not to be much.)

Give some reference about CO values and variability of CO in this region from measurements to assess the trend in CO over TWP.

P17 L354: 'This is consistent with our results which show intensified northerlies over the subtropical Indian Ocean and strengthened westerlies over the subtropical Indian Ocean and western Pacific' Please add some numbers in the text: how much is the strengthening. Is it a large or weak change. Please give the reader some numbers to assess this change.

P18 L377: 'In summary, the increase of CO as shown in Figs. 8a-8b is mainly caused by surface emissions.' My understanding is that the surface emissions are the same in the Control and Fixsst simulation and that the increase of UTL CO is caused by stronger upwelling. Please clarify.

Figure 11: '(a) Control run; (b) Fixsst run; (c) difference between the Control run and the 843 Fixsst run; and (d) JRA55.' --> labels a,b,c,d are not consistent to Fig.11. Why is MERRA2 and ERA5 not shown. How is the trend of the BD circulation calculated? Are zonal mean values shown? Please clarify.

P19 L384: 'The tropical upwelling of BDC (w^*) are significantly increased in the lower stratosphere over past decades as seen in both reanalysis data and the control run (Figs. 11a and b).' --> 'in JARA55 and control simulation'
Please indicate that the TEM is used to calculate w^* . Please specify 'significantly increased' with some numbers. Please compare the increase with numbers from other references.

P19 L400: 'The recent trends of the upward motion from the lower to the upper troposphere in boreal winter over the TWP is investigated for the first time based on the reanalysis datasets and model simulations.' Specify which reanalysis and which model runs are used.

P19 L405: 'Warmer SSTs over the TWP lead to a strengthened Pacific Walker circulation, enhanced deep convection and stronger upward motion over the TWP.' Please make this statement more quantitative. From the analysis it is not clear for me what is enhanced: convection or subsequent upward motion over the TWP by diabatic heating or both. How is downward transport over TWP by the Pacific Walker circulation during El Niño considered within the analysis? Please clarify?

P20 L410: 'Model simulations indicate that the CO concentration increases significantly from the surface to the stratosphere with increased surface emissions.' Please make the statement more quantitative.

P20 L417: 'Trace gases and aerosols in the stratosphere have important impacts on the stratospheric processes, and hence influence the troposphere weather and climate through their radiative and dynamical feedback'. This statement is very general. Please be more specific here.

My impression is that the conclusion section should be revised to summarize the results of Qie et al in a much more quantitative way.