Responses to the comments by Referee #2

Manuscript number: acp-2021-647

Title: **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**

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The revised version of the manuscript is much improved compared to the original manuscript and the authors did a lot of efforts to follow the reviewers advice. I recommend to publish the manuscript after some minor revisions.

Re: We thank for the reviewer's detailed and helpful comments. We have revised the manuscript according to the comments. The point-to-point responses are listed below.

1) Figures:

Most figures consist of different panels displaying the same x-y-ranges (e.g. Fig. 1, 2, 5, 6, 7, 9, 10, 11 and 12). To enhance the visibility and size of each panel I strongly recommend to remove x- and y-labels of some of the panels (e.g. display only x-label in bottom row and y-labels in the left column), panel titles as well as the white space between the panels.

Re: Thanks for the comments. We have updated all the figures as suggested in the revised manuscript.

3) Figures captions:

In the figure caption of several figures the text is very similar (Fig. 1, 5, 7 or Fig. 10, 11). There is a lot of repetition and the captions are a bit boring to read. I recommend to shorten some of the captions and use formulations such as 'Fig.2: The same as Fig.1, but...' to emphasize more the difference between the different figures. That would help to direct the reader's attention more to the main message of the figure.

Re: Thanks for the suggestions. We have updated the figure captions as suggested.

4) P7 Reanalysis data:

Maybe the authors could add a table summarizing the characteristics of the three reanalyses JAR55, ERA5, MERRA2 displaying horizontal, vertical and time resolution, considered time period etc. The text could then be shortened accordingly.

Re: Thanks for the comments. The text in the revised manuscript is shortened. And a table is added as:

Table 1. Basic specifications of JRA55, ERA5, and MERRA2 used in this study.

Name	Organization	Time period	Spatial resolution	Temporal resolution	Data assimilation
JRA55	JMA	1958-present	55 km; L60	6-hourly	4D-Var
ERA5	ECMWF	1950-present	31 km; L137	hourly	4D-Var
MERRA2	NASA GMAO	1980-present	0.5°×0.625°; L72	3-hourly	3D-Var

5) P9 L165: Please add a sentence (and some citations) why CO is a useful tropospheric tracer e.g. mention its lifetime.

Re: Thanks for the helpful suggestion. A sentence is added to the revised manuscript as:

"Since CO has a photochemical lifetime in the range of 2-3 months (Xiao et al., 2007), it could be utilized as a tracer of cross-region transport in the troposphere and the lower stratosphere (Park et al., 2009). Here, CO is used as a tropospheric tracer to indicate the vertical transport from the near-surface to the upper troposphere and the lower stratosphere."

6) P10 L190:

Also here a table summarizing the different features of the performed model runs would be very helpful to obtain an better overview and as a quick reminder when reading the results and summary section.

Re: Thanks for the comments. A table is added to the revised manuscript as:

Table 2. Description of simulations with WACCM4.

Experiment	Description
Control	**Transient simulation. Observed greenhouse gases and solar irradiances. Prescribed SST forcing using observed SST.**
Fixsst	**Transient simulation. Observed greenhouse gases and solar irradiances. Prescribed SST forcing using monthly mean climatology from 1958 to 2017.**
R1	**Time-slice simulation. SSTs prescribed as the climatological mean of 1998-2017 over the region 20°S-20°N, 120°E-160°E in NDJFM, but fixed as climatological mean of 1958-2017 over other regions.**
R2	**Same as R1, but the SSTs over the region 20°S-20°N, 120°E-160°E are prescribed as the climatological mean SSTs during 1958-1977.**

7) P20 Summary and discussion:

Also here for better comparability, I strongly recommend to summarize the results in a table showing the increase of upward motion resulting from the the three different reanalyses, from WACCM4 as well as the CO increase.

Re: Thanks for the comments. A table is added to the revised manuscript as:

Table 3. The trends of the upward motion over the TWP at 150 hPa, 500 hPa, and 700 hPa in NDJFM during 1958-2017 from JRA55, ERA5, MERRA2, Control simulation and Fixsst simulation. And the trends of 150 hPa CO from the Control and Fixsst simulations.

	JRA55	ERA5	MERRA2	Control	Fixsst
150 hPa Upward motion	**$3.0\pm1.2\times10^{9}$ kg s^{-1} $decade^{-1}$**	**$1.3\pm1.2\times10^{9}$ kg s^{-1} $decade^{-1}$**	**$3.0\pm2.8\times10^{9}$ kg s^{-1} $decade^{-1}$**	**$2.0\pm1.2\times10^{9}$ kg s^{-1} $decade^{-1}$**	**$-4.8\pm6.4\times10^{8}$ kg s^{-1} $decade^{-1}$**
500 hPa	**$4.6\pm2.6\times10^{9}$**	**$2.5\pm2.5\times10^{9}$**	**$5.4\pm5.3\times10^{9}$**	**$3.5\pm2.4\times10^{9}$**	**$-1.0\pm1.3\times10^{9}$**

Upward motion	**kg s^{-1} $decade^{-1}$**	**kg s^{-1} $decade^{-1}$**	**kg s^{-1} $decade^{-1}$**	**kg s^{-1} $decade^{-1}$**	**kg s^{-1} $decade^{-1}$**
700 hPa Upward motion	**$2.9\pm1.7\times10^{9}$ kg s^{-1} $decade^{-1}$**	**$1.9\pm1.6\times10^{9}$ kg s^{-1} $decade^{-1}$**	**$3.9\pm3.8\times10^{9}$ kg s^{-1} $decade^{-1}$**	**$1.8\pm1.4\times10^{9}$ kg s^{-1} $decade^{-1}$**	**$-6.3\pm8.1\times10^{8}$ kg s^{-1} $decade^{-1}$**
150 hPa CO	**--**	**--**	**--**	**3.4 ppbv $decade^{-1}$**	**3.2 ppbv $decade^{-1}$**

8) P31 L651:

'More observational data are expected to be used to obtain a more robust result in the future.' This sentence sounds odd, please revise it. --> 'The availability of more high resolution observations in the future could maybe enhance the quality of the reanalyses data.' Is that what the authors would like to point out here?

Re: The sentence is corrected accordingly.

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technical corrections:

P22 L434: remove '.' at the end of the subtitle

Re: Removed.

P29 L589 and L592: '(significant': remove blank

Re: Removed.

P31 L637: 'middle- and lower-troposphere': remove '-'

Re: Removed.

References:

Park, M., Randel, W. J., Emmons, L. K. and Livesey, N. J.: Transport pathways of carbon monoxide in the Asian summer monsoon diagnosed from Model of Ozon and Related Tracers (MOZART), J. Geophys. Res., 144, D08303,

doi:10.1029/2008JD010621, 2009.

Xiao, Y., Jacob, D. J., and Turquety, S.: Atmospheric acetylene and its relationship with CO as an indicator of air mass age, J. Geophys. Res., 112, D12305, doi:10.1029/2006JD008268, 2007.