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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sensitivity of stratospheric water vapour to variability in tropical tropopause temperatures and large-scale transport" *by* Jacob W. Smith et al.

Anonymous Referee #1

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In their manuscript Smith et al. describe an analysis in which they separate the contribution of varying tropical tropopause temperatures and varying transport on the amount of water vapour entering the stratosphere. They apply the concept of Lagrangian Dry Point along trajectories using ERA-interim data for the time period 1999-2009 and generated model data from the chemistry-climate model UM-UKCA. To distinguish between the effect of TTL temperatures and transport on the amount of water vapour entering the stratosphere, they time-shift either the temperatures (keeping the trajectories for transport as they would be for the specific years) or time-shift the trajectories for transport (keeping the respective temperature cycles fixed). Smith et al. found out that the variation in tropopause temperature contributes to 70% of the observed inter-

annual lower stratospheric water vapour variability and is the dominant driver for the annual cycle as well. Despite the important role of seasonal variations in tropopause temperature for the water vapour variability, transport contributes with 30 % in reducing the seasonal cycle maximum.

General comments: The paper is a very interesting and important contribution to the field of stratospheric water vapour. However, the text is sometimes difficult to follow and I don't understand what the text is aiming at in some parts. Moreover, I would suggest to shorten the text, focus on major results and omit results that do not contribute to the major findings. To understand the results, it is most important to understand the methods of time-temperature shift and time-transport shift. Here, however I had problems to reconcile the description in the text and Figure 1c. To understand your results, it is indispensable to understand the concept of time-shift methods, and this should be improved for the final paper. You divided your results chapter into the results of ERA-interim and model results. I suggest merging these chapters into one results section. This shortens the text and makes an inter-comparison easier. Moreover, the figures can be presented together.

The paper is suitable for publication in ACP after major revision.

Specific comments: Page 2, line 26: Please cite Stenke and Grewe (2005) here.

Stenke, A. and Grewe, V.: Simulation of stratospheric water vapor trends: impact on stratospheric ozone chemistry, Atmos. Chem. Phys., 5, 1257–1272, https://doi.org/10.5194/acp-5-1257-2005, 2005.

Chapter 2.1 and 2.2: Please include all aspects necessary for the description of the trajectory analysis in chapter 2.1. For instance: you say on page 5, line 131 (section 2.2), that you release the trajectories at the 83 hPa level. This information should be already available on page 4, line 96ff. It would also be nice to have an overview (table) over the important differences (period simulated, resolution of the data, release level of the trajectories ..) between the trajectory analysis for ERA and the model.

Page 4, line 97: Using 5580 trajectories for each initializing date means you use about 2 trajectories per grid point. Did you make a sensitivity test to show that your results are insensitive to that number? Please comment.

Page 4, line 106: Please highlight the formulae as an equation with a number.

Figure 3 b and d: I see the purple lines displayed as blue ones.

In figure 4, you switched the colours for the time-shifted transport from orange to blue (vice versa for the time-shifted temperature). This is a little confusing after reading figure 3.

Page 5, line 146: What do you mean by "pattern"? I would also suggest that there is a difference in the timing of the maxima in figure 2 between the SWOOSH data and the LDP calculation. Please comment.

Page 7, line 18: Please explain the term "generic" transport.

Page 8, line 250: Does "corresponding" mean that the coloured lines end at the month with the respective diamonds at 83 hPa? Please describe this more clearly.

Page 10, line 305: Please explain why the combination of initializing transport in August with temperatures in autumn leads to lower average SMR_LDP? From the text passage before, this is not clear to me.

Page 10, line 313 to 317: "For this temperature initialization date. . .SMR_LDF has a marked minimum, which appears consistent with the behavior of the time-shifted transport calculations discussed above." Please describe explicitly what is meant by "consistent with the behavior of the time-shifted transport calculations above."

Figure 7c: There is no structure visible in the figure. Please change selected range of the colour bar.

Page 11, line 47: Please specify what you mean by "any of the other features".

Page 11, line 58: Please specify what you mean by "cases".

Page 12, line 372: "which implies that cold points corresponding to LDPs will be cold relative. . .". I would suggest to write: "which implies that cold points corresponding to LDPs will be of very low temperatures relative.."

Page 12, line 393: "halving any arbitrarily chosen timescale results in an equivalent change in T_LDP and SMR_LDP". Please describe what is meant by "equivalent.

Page 13, line 403: Do you really mean that there is NO major change of LDPs over tropical America in figure 10? At least the change seems to be larger than over Africa.

Page 13, lines 404-405: You describe that the light blue symbols in Fig 9b are NOT re-evaluated from the original 6 hourly temperature calculations. This is, as far as I understand, in contradiction to what is stated on page 11, lines 359-360.

Page 13, line 405: "the difference between figure 10a and figure 10b is ignored"? Please explain in other words, what you wanted to say.

Page 13, line 405-415: It was hard to follow this text passage and there remain some questions: line 406: ".. does not require every trajectory to be search..". Why? What is meant by using "fixed LDPs". I looked through the text, but did not find a definition.

Page 13, line 419: How do you calculate backward trajectories when using zonally averaged temperatures?

Page 14, line 451: You state that vertical advection MAY be weaker in the model than in ERA-interim data. Why don't you look into the data and check if this is actually the case?

Page 14, line 460: You describe that the differences in saturation mixing ratios between model and reanalysis are difficult to explain. In line 455, however, you argue that the model trajectories probably do not sample the coldest regions of the TTL efficiently (as the ERA-interim trajectories do). As far as I understand, the last sentence is already

an explanation for the differences between ERA-data and model. Please comment.

Page 15, line 480: Do you mean “the seasonal variation in the fractional distributions” as indicated in figure 5 and 11 (lower panel i.e. 5c and 11c)?

Page 15, line 482: To which amplitude to you refer? This sentence is too long to understand, so please split it into 2 sentences of it and rephrase it

Page 16, line 518: What is meant by “without re-calculation the space-time positions of LDPs”?

Page 17, line 531: Please refer to the results section in which the importance of convective injection or particle formation or sedimentation were an outcome of your results.

Page 17, line 544: Please replace “cold temperatures” by “low temperatures”.

Page 18, line 562: “The generally stronger. . .”. The first part of the sentence is clear, but what does ”.. consistent with the seasonal variation noted previously of the amount of interannual variability . . .” mean? Please rephrase the text.

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