

Interactive Comment on “Climatological impact of the Brewer-Dobson Circulation on the N₂O budget in WACCM, a chemical reanalysis and a CTM driven by four dynamical reanalyses” by Minganti et al. 2019

In this manuscript the authors compare stratospheric transport processes in a state of the art CCM, in a CTM driven by four different dynamical reanalysis, and a CTM driven by chemical reanalysis. To do so they use the Transformed Eulerian Mean (TEM) framework to analyze the tracer budget of the long-lived tracer N₂O. The seasonal patterns, the annual cycle and the variability of the N₂O TEM budget (here the focus is on vertical advection and horizontal mixing term) at 15 hPa (higher stratosphere) are analyzed and compared between the different datasets. Overall the paper is of interest for ACP. However the manuscript should be highly improved in structure and wording! I have the feeling that in some sections the text lacks an organized structure. E.g. when describing the figures, the text jumps from one figure panel to another and it is really hard to follow. I recommend publication after carefully reading over the text again and rephrasing where it is necessary, and after considering the specific comments below.

Specific comments/questions:

- page 1, line 2: reword: “ ... from well-mixed tropical troposphere to polar stratosphere...”: This is a bit too short, here one has the impression, that tracers are transported directly from trop. troposphere to the polar region.
- page 1, line 7: insert “in ”-> in a chemical reanalysis
- page 1, line 10: have not been compared *before*.
- page 1, line 14: Please clarify, I do not understand the sentence: “....reflecting the large diversity in mean AoA obtained with the same experiments.” The present study does not look at AoA with CTM experiments.
- page 2, line 27: include that you compare interannual variability *between the different datasets*.
- page 2, line 33: reword and clarify this sentence to e.g. “The Brewer Dobson Circulation is characterized by upwelling of tropospheric air to the stratosphere in the tropics, followed by “. Note however that the BDC includes both residual circulation (net mass transport) and two-way mixing. Moreover the downwelling takes not only place in the high, but also in the mid-latitudes (change to-> extratropical downwelling) and not only in wintertime, although in the respective winter hemisphere it is much stronger.
- page 2, line 46: Why should mixing be limited to a specific latitudinal region of the winter stratosphere? In the surf zone mixing is only stronger. (see e.g. Fig. 1 in Bönisch et al. 2011)
- page 2, line 51: change to:” ... due to the increase in well mixed greenhouse gases (e.g. Butchart et al 2014,...) and due to increased ozone depleting substances (e.g. Polvani et al. 2018 ...) “
- page 3, line 56 and line 63: Here the study of Fritch et al. 2019 (<https://www.atmos-chem-phys-discuss.net/acp-2019-974>) is interesting.
- page 3, line 60: ... *observational* trends in the ...
- page 3, line 65: Say why is it important to do this separation?

- page 3, line 72: Could you write more about the study of Tweedy et al. 2017, as they are **also** looking at the N₂O TEM continuity equation in GEOSCCM!
- page 3, line 75: In Abalos et al. 2013 the stratospheric N₂O budget isn't shown.
- page 3, line 85: change to: ...four different dynamical reanalyses are used here to drive simulations
- page 3, line 88: Please clarify: Is only WACCM4 compared to BRAM2?
- page 4, line 93: Are there studies with CTMs driven by reanalyses that studied tracer transport in TEM framework?
- page 4, line 107-118: You explain the differences of WACCM-4 and WACCM-CCMI by model development. But are there also differences in the setup of the simulations (e.g. different SSTs,)
- page 4, section 2: I recommend to include a table to give an overview over the different simulations (CCM, CTM with diff. reanalysis).
- page 5, line 132: WACM-> WACCM
- page 5, line 137: ... as input...
- page 6, line 161: What do you mean with situation of interest?
- page 6, line 182: "N₂O balance" -> In this section you use tracer X to explain the TEM diagnostics, but here you change back to N₂O. Perhaps you use N₂O instead of X in the entire section?
- page 7, line 200: Can you be a bit clearer, please: You are giving the causes of the non-zero residual for WACCM, but what about the residuals in the CTM, and the chemical reanalysis? Is it only the timestep in BASCOE?
- page 7, line 205: "...while ..." -> "...even though ..."
- page 7, line 209: Note that Tweedy et al. 2017 looked at N₂O TEM budget at 85 hPa in the tropics.
- page 7, line 213: Why does w* vary in reanalyses data? Perhaps you can add one sentence more about Abalos et al. 2015.
- page 8, line 219: delete "the" -> are strongest ...
- page 8, line 220: You motivate the choice of the 15 hPa level with large differences between the CCM and CTM simulations in this region. Where do you see this? I suppose in Figs. 3 +4. And why isn't it interesting to see what is going on in the lower stratosphere?
- page 8, line 16: The terms, "vertical advection", "horizontal mixing" and their abbreviations Ay and My are mixed within the manuscript, even between one sentence these terms are mixed (e.g. page 8, line 225). Can you please use the terms consistently?
- page 8, line 226: "higher latitudes" -> I can see this mainly in the northern higher latitudes.
- page 8, line 232 (and also line 229): "... especially in the reanalyses Az and the residual play a **minor** role": I wouldn't say, that this effect is "minor"!
- page 8 line 238: spelling: reanalyses
- page 9, line 253: You only show three reanalyses here, not four.

- page 9, line 266: middle stratospheric ->middle stratosphere
- page 9, line 257: "(Fig. 3(f), (i), (l))" ->right columns of Fig. 3
- page 9, line 269: Motivate why you are choosing a single level in the middle stratosphere (15 hPa). What about the lower stratosphere?
- page 9-11, description of the climatological seasonal cycles: In my opinion this section is very hard to read, as the SH and NH are separated into two pictures. I recommend to merge Fig.5 and 6 to one Figure and then describe first the tropical, mid-latitude and polar N₂O (upper row), second the vertical advection Az (middle row) and third horizontal mixing My (bottom row). Thus it is easier to see the differences in NH and SH, the text is better structured and you do not have to repeat patterns that are similar.
- page 9, line 278-281: What do you mean with uncertainty – the 1 sigma standard deviation?
- page 9, line 282: " We first investigate the N₂O mixing ratio in the SH. In the tropic (Fig 5c and 6a)...." -> Fig. 6a is not in the SH!
- page 9, line 283: Please point out here more clearly, that BRAM2 is used as reference, and that this is the case for the entire section.
- page 10, line 286: change to: ...is smaller than in BRAMS in all simulations.
- page 10, line 284-288: You missed to describe the mid-latitudes....
- page 10, line 287: You wanted to talk about N₂O, not about Az and My...
- page 10, line 300: "...expect for JRA55" -> expect JRA55
- page 10, line 305: "It is yet comparable..." -> What? The uncertainty.
- page 10, line 311: Replace differ to different.
- page 11, line 337: Do you use the 1-sigma standard deviation?
- page 11, line 335-340: I think it is easier for the reader if you plot the standard deviation the same way as in Fig. 5+6. I do not see a real advantage of plotting the results in this order. And as recommended before it would be nice to have Fig. 7+8 in one plot and restructure the text accordingly.
- page 11, line 343: Why does the variability in WACCM-CCMI strongly depends on the considered realization? Shouldn't the internal variability between these ensemble simulations be similar?
- page 12, subsection "polar regions": The structure of this subsection was not clear to me during reading: you first write about the wintertime North Pole, then about the wintertime South, then you jump to the SH spring and to Antarctic and Arctic inter-annual variability. Perhaps you can give an introducing sentence of what you will discuss in this section.
- page 12, line 375: What do you mean with "Above the Arctic in the middle stratosphere ... (Fig.6)"? Do you refer to the 15 hPa level in Fig. 6?
- page 12, line 376: I cannot see that N₂O abundance in polar regions (Fig. 6c) are in good agreement in WACCM and BRAMS in the wintertime ...
- page 12, line 379: Compared to which reanalysis? To all? Before you were comparing with BRAMS.

- page 12, line 381: Replace “Fig. 6 bottom row”, to Fig. 6 g+h. And why are you talking about tropics and mid-latitudes here? In this chapter you wanted to discuss the polar regions.
- page 13, line 383: Do you mean the aging by mixing term in the polar regions of Fig. 2 in Dietmüller et al. 2018? Moreover reword “Note that ...” This is a poor transition between the two sentences.
- page 13, line 386: Include that TEM AoA budget was done in CCM simulations.
- page 13, line 391: Can you explain, why the TEM formulation is different in this study?
- page 13, line 392: “... agreement: our residual term is larger ...” But you are listing the differences here.
- page 13, line 396: Perhaps change to “...SH winter”. (Also in other parts of the paper)
- page 13, line 397: Again: What do you mean with “above 30 hPa”? Do you mean the 15 hPa level (latitude band 60-80S), as you are referring to Fig. 5?
- page 13, line 399: You are talking about Fig. 4, not about Fig 5!
- page 13, line 401: Are these studies are giving an explanation for the mixing inside the vortex. If yes, can you please give the explanation here.
- page 13, line 403: Make clear, that it is overestimated in WACCM ... (and overestimated according to what?)
- page 13, line 404: Change to : ... (see black thin lines in Fig. 4).
- page 13, line 405: You do not show the residual terms in Fig. 5.
- page 13, line 408: Say, why you are now looking at SH spring.
- page 13, line 409:” ... better agreement ...” Better compared to what?
- page 14, line 418: Replace “reanalyses” with dynamical reanalyses. And why is BRAM2 not included in this comparison?
- page 14, line 434: Please explain critical lines.
- page 14, line 448: vmr -> mixing ratio

Comments to the Figures:

- Fig. 1+2: Can you please replace “time der” to dN_2O/dt in the legend.
- You are showing different colorbars in Fig. 3 and 4!
- Fig 5+6, y-axis: Replace X with N_2O .

