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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The Tropical Tropopause Layer 1960–2100" *by* A. Gettelman et al.

Anonymous Referee #1

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The Tropical Tropopause Layer 1960-2100 By A. Gettelman, T. Birner, V. Eyring, H. Akiyoshi, D. Plummer, M. Dameris, S. Bekki, F. Lefevre, F. Lott, and C. Bruehl

This paper represents a model intercomparison study of the tropical tropopause from the past to the future. The scientific questions raised are of high priority and within the scope of ACP. The work contains novel concepts and ideas. However the overall presentation of the paper is not so well structured and clearly written as is described in detail below. There are many oversights in the manuscript.

Besides this, some fundamental details are missing, which have a large impact on the overall results of the paper. The interpretation of the model results concerning a model resolving TTL might be miss-leading.

More specific, I have found two major problems, which impact the overall conclusions of the paper: 1) I rather doubt that the CCM models used are of high enough vertical

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Interactive Discussion
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resolution to resolve a TTL, which is located between ˜14 and 18 km altitude between maximum convective outflow and the cold point in the tropics. No details are given at all concerning the vertical model levels (hybrid model levels) or the standard output resolution from the CCMs and assimilations systems used. This should be done within this paper as these details are very critical for the interpretation of the model results and should not be linked to Eyring et al, 2007. Regarding to this problem the title of the paper should be changed to "The Tropical Tropopause 1960-2100".

2) The trend (analysis and) interpretation should be avoided with the NCEP/REA and ERA40 re-analyses as there are very well-known problems of the assimilation systems in the tropical tropopause/TTL already published by many authors (Fueglistaler et al., Randel et al, Gobiet et al, Uppala et al, Seidel et al, Dhomse et al., Krueger et al, Konopka et al). It can't be that the authors are total avoiding this body of well accepted literature. Whether you avoid this trend interpretation in your ms totally or carefully discuss it plus using more reliable observations to compare with e.g. HadAt2, CHAMP or quality checked radiosondes.

Specific comments:

Introduction:

- A motivation is missing why is it meaningful to do this tropopause study see your questions and answers in the conclusions.

- There are many repetitions of words within the introduction, please avoid this and re-write your intro: region (Page 1368), TTL 13x on Page 1369 within one sentence up to 3 times

- Add volcanoes as a natural variability for the TTL.

- Page 1369 lines 7-10 add missing references here: e.g. Gettelmann et al. 2001, Fueglistaler and Haynes 2005; Krüger et al 2008.

- "Several studies..." line 17-4(1370). The sentences are only lined up, please re-

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write and add more relevant references e.g. add Lagrangian TTL studies (complex 3D structure of the TTL) > Bonnazola and Haynes 2004, Fueglistaler et al 2004 and related work.

Page 1370:

- "multi-model ensemble run" > "multi model ensemble" no run

- Line 23: 1980-2100 or 1979-2100??? In table 3 it says 1979-2001, etc. Be precise with the years. This is used differently throughout the whole ms!

2. Methodology

Page 1372:

- LZH was already written out, repetition

- Add a cartoon picture to clarify your 5 acronyms from table 1. Otherwise very unclear what you mean here.

- 2°C or 2K !

- "1960 or 1980 to the present" what should be present here? See the details from table 3: 1960-2001 or 1979-2005, 1979-2001 1960-2004; present means here 2001, 2005 and 2004? A lot mixed up details here!

- Transient run : what means transient here? Incl. SSTs, volcanoes, QBO and solar cycle? This is very important detail for the trends and variability you are referring later on!

Page 1373:

- 1980?

- NCEP and ERA40 data vertical resolution? Did you use the 23 standard pressure levels or the 60 model levels from ERA40?

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Page 1374:

- line 2: reanalyses use Pl.

- Analysis 2.3 : Add all the details of the vertical resolutions here a) the hybrid model levels, b) the standard model output used for this study!

- Son et al 2008 seems to be very important for this paper here, but it is not available for the readership. Please add a web link to it or cut the reference out of the whole ms.

Page 1375:

- Line 1: abbreviations w/o the Figure location > (CPTT) instead of (CPTT-top) see the other examples as well.

- "on model levels" see my comment before.

- Concerning the multi-model ensemble trend: is it clever to calculate a multi-model ensemble trend if the spread of the models is so large? If you still want to do this you need to give the numbers of the trend uncertainties/spread as well! (see table 3).

3. Multi-model climatology

Page 1376:

- 8-10: repetition of the figure caption text in the ms text as well, cut this out.

- "the lowest CPTT occurs from Jan-March": Really in March? Please cite papers for this as evidence! -Line 18-20: mention cold bias problem of GCMs in the tropics (Pawson et al, 2000 BAMS).#

- 23-24: Figure 5b: order of figures in the text does not correspond to the order of the figures itself!

- "Variations are due to model level resolution and vertical interpolation to standard pressure levels" which are?

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- "indicate about 1-2 K temperature differences" Between what?

- "It also makes it difficult to know how much the CPTT is affected..." very vague!

Page: 1377:

-"which maybe a bias in the analysis or due to coarse vertical resolution..." only two papers are cited here, but there are many more papers directly addressing re-analysis problems in the TTL! Cite more papers and give more examples this is really not reflecting the research going on.

- "The cold point is ALWAYS... the same level": this is not true for reality and maybe only valid for this CCM study which seems to be biased by the standard model output used.

- "92-102 hPa": How can you extract different pressure levels for the LRTP if you are using standard model output???

- Line 21-26: How meaningful is such an intercomparison/analysis, if you are restricted to only 2D output?

4. Long term trends

Page 1378:

- Line 3: double correlation

- Ref1: 1960-2005 table 3 say 1960-2004 ?

- The whole paragraph from 15-25: So far no "real" TTL paper using assimilations is trying to argument that there are trends in ERA40 or in NCEP/REA so this paper should also avoid this (see general comment above)!

Page 1379:

- "are 50% larger": from table 3 I derive less?

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- "other work with models" which models/ observations?

- "These changes represent": Not the changes but the CPT represents the top of the TTL, change words.

- Use your abbreviation LRMP instead of LRM pressure.

- "significant trends" where are the significances?

- Fig. 6: Add ULAQ shows a strong offset.

- Trends in re-analysis: leave them out! Or use other independent reliable observational data sets!

- LRM can vary with model formulation” But why? more details or leave this out! - At each ˆgridˆ point: add ˆˆ

Page 1380:

- "in the subtropical stratocumulus regions" cut stratocumulus out or provide more evidence for this interpretation/statement.

- Ascent rates in MAECHAM are too high/low? Add this information.

Page 1381:

- Line 1: "There is also a" Where?

- "due to large inter-annual variability": But the models IAV is smaller than the obersved one? Contradiction in your arguments.

- "Ab scenario" ?

Page 1382:

- "Since trends are broadly linear...does not change..."; Not true, the circulations changed in the mid 1970s $>$ step-wise change! No trend calculation should be carried out over this whole period.

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- Line 8. which may be ˆrelatedˆ to: instead of ˆcoupledˆ

- Figure 13: only show future trends from 2006-2050 from WACCAM!!! It should fit to the rest of the paper.

Page 1383:

- Fig 13a: This dumbbell pattern looks like the typical ENSO pattern in the TTL, add this info.

- Fig 13 a and d do not fit together, add this in the ms.

- "The multi-model ensemble indicates no significant trend..." Where are the significances given?

5. Discussion

Page 1384:

-Line 12: The questions raised here should be clearly brought up in the introduction already as a motivation!

5.3:

Page 1386:

Fig. 16: Where is the NCEP dot? It is not in my figure 16! Add NCEP.

Page1387:

- lines 10-12, unclear sentence.

6. Conclusions:

-"differences are related to the fundamental climatologies". Which are?

- "warmer temperatures" should be higher temperatures

- "Thus models are able to represent the TTL structure"; cut this sentence out.

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Interactive Comment

Figures/Tables:

- table 3: time periods /years inconsistent

- Table3: add the spread/uncertainties of the model trends "+/-..."

- All figures are far too small!

- Figure 2: Ref1 years are in contradiction to table3.

- Figure 3: Add the used vertical levels in the figure, years.

- Figure 4: Use reliable observational data set here as well e.g. based on radiosondes!

- Figure5: How can you derive variations of the LRTP when using vertical standard output?

- Figure 6: Cut Figure 6 out as it is not meaningful too large spread! See your own text.

- Figure 7: WACCM plots are shown from 1950-2005 why are you using an other period here? You should be self-consistent within your paper! Start with 1960! Add longitudes at the x-axis. Same style as in figure 13 hard to distinguish colours.

- Figure 8: Re-order plots first 8 b and then 8a.

- Figure 10: Why are you using different colours now? Add Ncep and EAR40 in red and stay with your old colours, be consistent within your ms.

- Figure 13: Calculate the trends for 2006-2050, why starting in 1975? This remains totally unclear! Contradiction between fig A and D.

- Figure 14: Add legend.

- Figure 15: Figure caption: Add "past and future scenarios"

- Figure 16: NCEP/HALOE dot is missing!

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