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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 #2

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This paper examines the latitudinal structure, seasonal cycle, and long-term trend in TTL properties as simulated by 13 CCMVal models. These models have high vertical resolution and fully interactive stratospheric chemistry. One may therefore expect that they capture realistic spatial and temporal structure of the TTL. In fact, authors found that CCMVal models successfully reproduce some (not all) of TTL properties as in the reanalysis data for the recent past. Given this similarity, authors extended their analyses to the future climate. They found that ZLRP, LRTP, and LRMP, which show statistically significant trends among many other TTL variables, will decrease in the 21st century as in the recent past.

This paper is providing very useful insights on how well current generation of the CCMs are able to capture the spatial and temporal structure of the TTL. Analyses are laborious but well done. However, I found that this paper can be improved substantially by addressing the following issues.

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Discussion Paper

1. Data

MRI data archived in CCMVal ftp site are interpolated twice: e.g., interpolation from the model levels to reference pressure levels, then to CCMVal standard level. The evaluation of LRT and ZLR with these data could be misleading, as indicated by authors for GEOSCCM. I suspect other models might have similar problem. I strongly recommend authors to check multiple interpolation issue for all models one by one.

2. TTL variables

As indicated by authors at L162, zonal-mean CPT calculated with zonally-monthly-averaged temperature may be different from that with 3D temperature field. But, no comparison is made. Authors may be able to compare them at least for WACCM and CMAM (no figure). It will provide some confidence to CPT analyses.

The width of TTL is often interpreted as the width of Tropics. I think it is correct. But, to make sure, authors may want to compare the seasonal evolution and long-term trend of TTL width to those in Hadley-cell width at least for WACCM and CMAM (no figure).

3. Inter-model difference in TTL variables.

There are huge inter-model difference in TTL variables. Authors argued that it might be related with difference in model formulation and resolution. It could be. But, more important questions are: 1) is that because of the differences in tropospheric or stratospheric processes? 2) If stratospheric processes are responsible, is that related with difference in stratospheric chemistry? In other words, what do CCMs need to be improved to capture more reliable TTL? Although quantitative evaluation is difficult, authors can try qualitative evaluation such as scatter plot analyses. For example, Son et al. (2008, referred frequently in the paper) showed that UT temperature trends are quantitatively similar in all 6 CCMVal models they examined. Given the wide range of model physics and resolution, this result is remarkable. They found that the difference in LRTP trend among CCMVal models are primarily due to the difference in LS tem-

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perature trends which are associated with stratospheric ozone. Similar analyses can be done with respect to the stratospheric ozone, SST, model resolution, and so on.

4. Different TTL trend between the past and future.

From the climate change perspective, the difference in TTL trends between the past and future is quite interesting. Although authors did not emphasize, Table 3 shows that ZLRP and LRTP are predicted to decrease in the future as in the recent past but with a trend much weaker than in the recent past. Why? Although the exact reason is difficult to find, authors should discuss some possible reasons (although speculative).

5. Interpretation of TTL expansion

I agree with authors that weaker TTL expansion in CCMVal models is associated with with coarse horizontal resolution. But, I think it is not because of the inadequate resolution to measure the trend but because of the underestimated eddy activities in the extratropics. As discussed by Lu et al. (2007GRL), Hadley cell expansion is associated with extratropical eddies. Since coarse model resolution could result in weaker eddy activities, it might be responsible for weaker expansion of TTL. The detailed analyses are obviously beyond the scope of this paper. But, authors should address the possible role of eddies on the width of TTL in the discussion section.

Minor comments

L225. Use italic instead of capital ALWAYS.

L270. Delete pressure in front of LRTP

L293. I don’t think that Fig. 7a is coherent with Fig. 7d. While Fig. 7d shows ENSO-like dipole pattern, Fig. 7a does not. Need further discussion.

L296. Use western Pacific instead of W. Pacific. Same to other sentences.

L296. Authors argue that SPCZ shifts equatorward. But, I do not see that in Fig. 7. Need further clarification.

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L468. Replace SVMR with Qsat.

Fig.1c. Replace minlrp with lrmp at the panel top.

Fig. 4 and others. Why don’t you use full model name: e.g., UMLIM -> UM-SLIMAC

Fig. 12. CCSRNIES and MRI do not have interannual variability but have linear fit. Plotting error?

Fig. 16. Make HALOE/ERA40 bigger.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 1367, 2008.