Geoscientific
Model Development
Discussions

Interactive comment on "Description and evaluation of tropospheric chemistry and aerosols in the Community Earth System Model (CESM1.2)" *by* S. Tilmes et al.

Anonymous Referee #1

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General comments:

The manuscript by Tilmes et al. describes the model configurations available for tropospheric and stratospheric chemistry in the Community Earth system Model, known as CAM-chem for the versions CAM4-chem and CAM5-chem. Free running and nudged model versions as well as specific sensitivity simulations are compared and the model configurations are evaluated against observational data. Since CESM and CAM-chem are widely used global models, the importance of this paper is undoubtful. The model configurations are introduced carefully and numerous observational data relevant for global model evaluation has been used. The authors show that CAM5-chem is ready for use by the community, even if certain shortcomings are still present in the latest

version. This particularly applies to the bias in methane lifetime, which is even lower in CAM5-chem than in CAM4-chem. The paper reads smoothly for most sections, although working through all 24 figures is a bit exhausting, given that the information content of most figures is very dense. In my specific comments I try to give suggestions which of the figures could be omitted or condensed. In general, I recommend to publish the paper if the following specific comments will be addressed.

Specific comments:

Abstract:

In the abstract I am missing important findings from section 4, notably the general performance for tropospheric ozone and other important trace gases and aerosols (this is summarized in Section 6 only).

8877, 10-12: Mention underestimation of observational data for methane lifetime.

Section 1:

8878, 10: Additional references would be desirable (e.g. Isaksen et al., doi:10.1016/j.atmosenv.2009.08.003).

Section 2:

8879, 26-27: The term "data ocean" is not known to me. Re-formulate the sentence to "All model simulations are performed with prescribed sea surface temperatures and sea-ice distribution data for present-day climatological conditions, . . ."

8884, 5: You may think about a different naming instead of "CAM5-chem*". This term is also not searchable with Adobe Reader.

8884, 10: Replace "performance" by "setup and global model diagnostics".

Section 3: One could think of adding more surface station data to the evaluation data base, notably Ozone and other species or aerosol parameters from global or regional

air quality networks, but this may be beyond the scope of the paper. At least the choice of evaluation data should be discussed for their relevance.

8884, 22-25: I found this very confusing. Why using MOPITT here? The sentence seems not to belong here.

8886, 25-27: Please clarify the meaning of a "profile-to-profile" comparison. How are observational data and model results matched in space and time?

8887, 21-27: The first part of the sentence until "...(Table 2)" is an unnecessary replication and can be skipped. Instead, another sentence to introduce the IMPROVE measurements would be useful.

Section 4: In section 4.2, the evaluation should be ordered strictly by species (groups). In particular, all CO evaluation should be placed after the ozone evaluation.

I cannot follow the argumentation when it comes to NH lower troposphere ozone differences between CAM5-chem and SD-CAM5-chem, as it is done in Sections 4.2.2, 4.2.3, and 5. From what is presented in the paper, the relation of BL tropospheric ozone to STE in the model configurations seems to be weak (or vague). A more stringent argumentation chain will be appreciated by the readers.

8888, 25-26: When TTL is defined by pressure levels 150-70 hPa, you can see from Fig. 1 both higher and lower ozone mixing ratios.

8890, 1-5: Write out COSMIC. These observational data, together with MLS and AIRS, need to be introduced before. Also, the observations give different cold point altitudes. All in all, Figure 3 is not really exploited. The whole paragraph (8889, 26 – 8890, 9) together with Figure 3 could be skipped.

8890, 10: Fig.4. goes higher up than 30 hPa.

8890, 20-24: Instead of showing Fig. 5, AOA could be assessed by simply comparing AOA entries for a certain height, which can be given in Table 1.

8892, 13-16: CAM4-chem and CAM5-chem results are not shown in Fig.7.

8892, 25-27: This is only true for free tropospheric SO4. SO2 is largely underestimated.

8893, 9-13: I cannot see any significant and systematic differences between the model configurations, at least from Figure 9. I suggest to skip these sentences.

8894, 14-22: The whole paragraph would better fit to 4.2.4.

8894, 15: Is this total column or tropospheric column (as Figure 11 suggests)? In most studies, satellite CO used for evaluation is total column.

8894, 17: It seems you were misled by the color coding in Fig. 11. There is no significant high bias for CAM4-chem for most of the year.

8894, 26: The better agreement of SD models with observations for high latitudes cannot be derived directly from Figure 11.

8895, 20-21: Be more honest here. Modelled ozone has deviations of up to 25% for larger world regions.

8896, 5-10: I am not convinced here. There are regions with reduced cloud fraction over the NH but also regions with larger cloud fraction. Also, the implications for ozone of cloud differences over Africa and the Middle East are not obvious. Wouldn't it be more illustrative (also for the mid latitude differences) to show differences in modelled ozone production?

8896, 11-15: Again, the model bias is up to 25% in Figure 13 and up to 40% for the aircraft data.

8896, 17-19: "Especially ... observations". Skip this sentence or re-phrase.

8896, 23: Compliance of model results with aircraft observations over Europe and US is not shown.

8897, 9-10: The 250 hPa level is not stratospheric.

8898, 7-10: Specific campaigns are not shown directly by the figures.

8898, 19-21: HNO3 nor NOy are shown in Fig. 20. Fig. 15 does, but gives no clear answer.

Section 5: 8899, 13-16: Re-phrase this sentence. "As shown in model intercomparison projects projects like ..., the reason for differences cannot be easily ascribed ...". Give references here, e.g. Naik et al. (2013) or Voulgarakis et al., doi:10.5194/acp-13-2563-2013 .

8899, 22-25: This has been already described in Section 4.2.5.

8899, 27 – 8900, 4: Be more precise here and in Figure 22. Is it tropical CO burden or tropospheric CO burden or both. Similar for the Methane lifetime: Atmospheric or tropospheric?

8900, 16 - 8902, 9: I guess that all burdens mentioned here are tropospheric burdens. This should be mentioned somewhere.

Section 6: 8902, 15-21: Overestimation of surface SO2 and SO4 for polluted regions points to an overestimation of emissions here?

8903, 9-11: As said before, I don't agree with this conclusion: Deviations are up to 25% for ozonesondes (Fig. 13) and up to 40% for aircraft campaigns (Fig. 15).

8903, 14-15: Looking at Fig. 11, the bias looks more like 25-50% for the southern extratropics.

8903, 23-24: A general underestimation of NOx is not supported by Figs. 15, 19 or 20. Instead, both overestimation and underestimation can be found.

Table 1: Exchange "model performance" by "global model diagnostics".

Table 1: Add AOA as model parameter. Make sure that all burdens are atmospheric,

otherwise say "tropospheric burden".

Table 3: Entries for the following abbreviations are missing: AERONET, AIRS, AMWG, CLM, COSMIC, MACCity, MOPITT, MOZART, WMO.

Fig. 1: How is SAD TROP in the stratosphere defined? You could mask this area in the top right panel.

Fig. 1: I guess differences in RH are relative differences, but this is not clear from the figure caption (also in Fig. 2).

Fig. 10: replace "Kinne (2009)" by "(Kinne, 2009)". Add "(model – observations)" after "Differences".

Fig. 11: Are tropospheric columns (as in the figure title) or total columns (as suspected from the text) shown?

Fig. 11: From the main text this is an OMI/MLS climatology.

Fig. 14: Frames for aircraft campaigns are hard to see (also in Fig. 19), those are also not really needed for the paper. Re-Phrase the Figure captions.

Fig. 15: It is not obvious how the temporal and spatial match between campaigns and model results has been achieved for this Figure (and Fig. 18).

Technical corrections:

8879, 2: Reference for Liu et al., 2014 is missing.

8879, 9: replace "Strength'" by "Strengths".

8880, 2: Write out "CLM".

8882, 1-2: Remove "chemistry including".

8883, 8-10: Add reference: Rienecker et al., http://dx.doi.org/10.1175/JCLI-D-11-00015.1 .

8883, 15: For clarification say "prescribed chemical fields for longer-lived substances".

8883, 27: Add "with" before "lower".

8884, 14: Replace "We are interested in..." by "We limit ourselves to...".

8884, 22: Write out "MOPITT".

8885, 15: Replace "TERRA" by "Terra".

8885, 20: Write out "AERONET".

8886, 6: Skip "between 1995 and 2010".

8887, 10: Replace "... similar regions and different seasons ..." by "... similar regions in different seasons ...".

8889, 28: Add "as" before "described".

8890, 10: Replace "... are analyzed..." by "...is analyzed...".

8890, 18: Replace "configuration" by "configurations".

8892, 19: Add "free" before "troposphere".

8892, 27: Data is shown in Fig. 8, bottom right panels.

8894, 7: Replace "Column" with "Columns".

8895, 17: Add "ozonesonde" before "observations".

8896, 26: Figure 17 must become new Figure 16, as it is introduced first.

8896, 26: Replace "Fig. 17 first and second column" by "Fig. 16, first and second row".

8897, 5: Add "(Fig. 17)" after "biased high".

8897, 8: Skip "(Fig. 16)".

8897, 21: Exchange "(Fig. 15)" by "(Fig. 18)".

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8898, 7: Exchange "(Fig. 18)" by "(Fig. 15)".

8898, 17: Add "free" before "troposphere".

8902, 2: Add "at" after "pointing".

8909, 3-5: Please use correct doi: "doi:10.1029/2004JD005537".

Table 2: Skip ", starting 1995".

Fig. 1: Exchange "SD-CAM4-cam" by SD-CAM4-chem" in the figure caption.

Fig. 3: Re-phrase figure caption: "Comparison between zonally (20°S-20°N) and annually averaged fields of ... around the tropical tropopause region, derived from ...

Fig. 7: Replace "SD-CAM5-chem (blue) and SD-CAM5-chem (red)" by "SD-CAM4-chem (red) and SD-CAM5-chem (blue)".