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Interactive comment on "Quantitative evaluation of ozone and selected climate parameters in a set of EMAC simulations" *by* M. Righi et al.

Anonymous Referee #2

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This manuscript presents a comprehensive evaluation of a chemistry-climate model against a range of observational datasets using ESMValTool, which is freely available for use. They authors also explore differences in 4 EMAC model set-ups, some of which have been used for previous studies. The analysis presented is not only of interest to those who run the EMAC model, but to the wider community due to the comparison of nudged models against free running models and the examination of the several chemical species to the introduction of new chemical reactions. The paper is well written and clearly structured and I believe it is well suited for publication in Geoscientific Model Development after the authors address the relatively minor comments below.

General comments: I find it quite difficult to follow the differences in the 4 different model simulations. It would be helpful to have a table that lists all the relevant dif-

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ferences. For example, yearly-varying emissions versus non-yearly varying emissions and which inventories used, driving meteorology (for nudged) or stating free-running, climate feedbacks or not, etc. This is done slightly in Table 2, however a more comprehensive summary table would be useful.

For temperature (figure 1), can you say why the free running models perform better at high altitudes compared with the nudged? This seems to coincide with the regions where the nudging is not applied (above 97 hPa)? What is the difference between the way the climate variables are calculated between the nudged model outside of the nudging region and the free running model? Why is the nudging not applied throughout the whole model domain?

Is the cold bias in the nudged models (seen at 200 hPa in figure 2) due to differences between ERA-operational and ERA-Interim? I wonder how this compares to other non reanalysis temperature datasets? Maybe there is something in the literature? Dee et al., (2011) - The ERA-Interim reanalysis: configuration and performance of the data assimilation system shows a larger RMSE in ERA-operational than ERA-Interim at 200 hPa when compared to radiosondes.

For upper tropospheric ozone, you mention that differences between EVAL and QCTM can be explained by differences in lightning emissions. I noticed that lightning emissions are also similarly high for the free running simulations, however, you don't mention this in the section 6.2.2 discussion. The free running models also have high ozone in figure 13 and 15 in some regions. Do you think this is related? Also EVAL and QCTM have different aircraft emissions, could this also be having an impact? What is the difference in the amount of emitted aviation NOX for these two model runs?

For OH, it is still useful to quote the global mean tropospheric OH concentration for the different simulations as these can be used to compare the oxidative capacity of different models. Please calculate and add a table giving the mass-weighted tropospheric OH. It would also be useful to compare to other multi-model mean values quoted in the

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literature. It would be particularly interesting to know the global mean OH calculated for the ACCMIP-S2 run to know how much this new channel is reducing OH. I assume it is by quite a bit due to the impact seen on CO. You state in your conclusions that the improvement in UT O3 due to this channel supports the need for it to be included in models, knowing the impact on OH could further support or counter this. You can compare your values to global mean OH concentrations constrained by methyl chloroform.

Minor comments: Pg 6551, L16: give example of 'climate variables' (e.g. temperature).

Pg 6552, L1: 'stratospheric input' - of what ? Do you mean being transported into the troposphere from the stratosphere?

Pg 6553 and Pg 6555: You describe/state you use different versions of MESSy in several places. You can remove initial mention of this on pg 6553 (L18-19). When I read this section I was wondering why you were using two different versions of MESSy as you don't say why. It later becomes apparent that this is because you are using another model simulation that has been done for a different study. Try and combine these two descriptions somehow to make less confusing.

Pg 6554 L8-L9: I find it hard to know what you mean here.

Pg 6554 L22-L23: Mention use of offline aerosol after you mention heterogeneous reactions, before description of convection at L16.

Pg 6554, L20: Can these be used to perturb the climate/dynamics of the model?

Pg 6556: Why do you apply scaling to ship emissions to estimate transient changes in emissions but don't do same to the anthropogenic emissions? I feel it would be best to be consistent in your treatment of emissions. Why do you not use the road traffic emissions from the Lamarque et al. dataset?

Pg 6557: Why are the aviation emissions tuned lower?

Pg 6560, L12: How do you choose the 'reference' dataset? For example, the one with

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the lowest measurement uncertainty? Or the one with the biggest spatial/temporal coverage? Or maybe more simply this is what is already implemented into the ESMValTool ?

Pg 6563, L24: State drawbacks of using aircraft data for this sort of general evaluation – for example the fact that you are using emissions which don't match the year of observation. This would mean that for measurements gathered near sources, such as fires, which have a high inter-annual variability you may see large model biases.

Pg 6565, L11 – 13: Maybe state the 'positive bias' is against the HadISST dataset, which is used to drive the TS2000 simulation.

Pg 6565, L 12: Hard to compare inter-annual variability between levels as the plots are on different axis ranges. Have you calculated standard deviation weighted by the mean anywhere? This would give comparable values between levels.

Pg 6567, L11-14: Maybe mention that this is the upper limit of where nudging applies.

Pg 6567, L19: Change from 'slightly weaker' to 'lower amplitude'?

Pg 6568, L1: Is there any particular region where these uncertainties are more common? High vs. low alts or tropics vs. extra-tropics? You can see from Fig 2 that the largest differences seem to occur in the upper troposphere in the tropics.

Pg 6568, L2: reference the appendix where you describe Taylor diagram

Pg 6569, L17-21: 'The underestimation' onwards - Slightly repetitive, combine sentences or shorten?

Pg 6569, L28: Insert 'observational datasets, particularly in the tropics'

Pg6570, L6: What do you mean by 'simulation of the mean'?

Pg 6570, L17: Not sure I agree with 'generally good agreement'. Fig S7 shows models are generally biased low at 500 hPa, 30hPa and 5 hPa.

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Pg 6570, L25: Why is 400 hPa more significant?

Pg 6570, L26: 'In the extratropics,' – 'In the extratropics near the surface,'

Pg 6571, L19: Where is the EMAC CERES comparison shown? If not shown then state 'not shown' in brackets.

Figure S11. Give units in caption.

Pg 6571: Can you say why the free running models tend to do worse? This is particularly evident in the long wave radiation comparison. Is this maybe something to do with the clouds that are calculated for the free running models? It would be useful to discuss this in a bit more detail at this point to give some idea of the uncertainty in calculating clouds for free running models.

Pg 6572, L3. Need to mention what these sensitivity runs are previous to this point as they are shown in Fig 9 onwards. Put description in section 2.

Pg 6573, L15: What is the bias in the model in this SH peak ozone column?

Fig 10: I think this can be moved to supplementary material. Also the lines are hard to differentiate between models.

Pg 6574-Pg 6575: Can you say something about the accuracy of total tropospheric column ozone from the MLS/OMI measurements? It would be good to know whether the model lies outside of this uncertainty range.

Pg 6576, L9-10: Not clear which model runs you are referring to here, give names of runs to be consistent.

Figure 15, Pg 6576: I think you need to make it clear in the figure that the 'SH extratropics' comparison only includes 2 stations and 'SH tropics' only includes 1. A table or map giving the station locations in the supplementary material would be useful.

Pg6578, L3: Add reference. Also mention that at very high concentrations of NOX

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ozone production become less efficient (so near source regions).

P6578-6579: I think the surface comparisons are of much better value then the aircraft comparisons as CO will have very high concentrations sampled by aircraft targeting emission sources such as biomass burning and anthropogenic emissions, switch the order of discussion (surface comparison first) and also mention the problem with using aircraft data climatology to evaluate models for a specific year.

Pg 6579, L20-24. Models generally underestimate winter/spring tropospheric CO in the NH. This has been shown by Shindell et al., (2006); Shindell et al., (2008); Monks et al., (2014), ACPD (POLMIP multi-model comparison) against several other datasets. The reasons for this underestimate are still not fully understood.

Pg 6579-6580: Several models have also been shown to underestimate ethane and propane in the northern hemisphere against surface data, see Emmons et al., (2014) in ACPD (POLMIP multi-model comparison).

Pg 6582, L15-16: I think this CO change is due to a reduction in OH (you say this on line 11) so it is not going to influence the OH in return. However, the original OH change could increase the methane lifetime directly having important implications for climate.

Pg 6583, L23: with exception of aviation emissions?

Technical Corrections: Pg 6551, L 12: model not models

Pg 6552, L19: insert comma before 'which'

Pg 6553, second para: Mixture of Sect. and Section (line12).

Pg 6553, L12: replace given with described or 'description of observational data given in . . .'

Pg 6553, L23: Make version plural or Just state 'MESSy uses. . .'

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Pg 6555, L19: insert commas - ‘,as much as possible,’

Pg 6555, L21: replace ‘particular’ with ‘this case’ or ‘in this simulation’

Pg 6556, L19-20: change ‘from the GFED 3.1’ to ‘from the GFED v3.1 inventory’

Pg 6556, L20: add ‘x 0.5’

Pg 6556, L21: change ‘also consider’ to ‘also use’ or other.

Pg 6599, L11: remove also.

Pg 6563, L25: remove ‘again’

Pg 6566, L13: replace ‘and thus related to the representation of’ with ‘, coinciding with’

Pg 6568, L15: Insert commas ‘which, analogously to EMAC, are’

Pg 6569, L26: ‘As for the temperature’ -> ‘As found for temperature’

Pg 6570, L27: insert comma after year.

Interactive comment on Geosci. Model Dev. Discuss., 7, 6549, 2014.