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Interactive comment on "Description and evaluation of the UKCA stratosphere-troposphere chemistry scheme (StratTrop vn 1.0) implemented in UKESM1" *by* Alexander T. Archibald et al.

Anonymous Referee #1

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The manuscript by Archibald et al. presents an exhaustive description of the latest version of the gas-phase chemistry scheme implemented in the UK Earth System Model. The documentation includes a description of the gas-phase chemical mechanism that is applicable to the troposphere and middle atmosphere, as well as a description of associated processes such as photolysis, wet and dry deposition and interactive emissions such as lightning NOx. The discussion then moves on to presenting diagnostics of the behaviour of the model in both the troposphere and stratosphere.

The manuscript is well laid out and the presentation of the model components and diagnostics of the model behaviour are clearly discussed. My only significant criticism

is the length of the paper. I understand the need to document the many different components of the model and the authors do a good job of referring the reader to other papers for a more in-depth discussion of various model components. But the inclusion of large tables providing the list of all chemical species and reactions in the main body of the manuscript forces the reader to push through many pages before the discussion continues. I strong urge the authors to move many of these tables (Tables 1, 2, 3, 4, 5, 6, 7, 8 and 9) into the supplementary material and provide the reader with a much more compact description of the important facets of these model components. In addition, in the detailed comments for Pages 31 – 35 there is additional material on emissions that I would suggest the authors re-consider in the interest of making the paper easier to get through.

After having said all that, a few suggestions to make the paper longer... Could the authors include a very short description of how polar stratospheric clouds are treated in the model? I could not find any information on how these are calculated in the model. Note that there is a reference to Denison et al. (2018) in the caption for Table 5, but the reference is missing. And while a significant part of the paper is dedicated to assessing the stratosphere in the model there is no presentation of the total column ozone climatology that is produced by the model. Such a basic and well-observed quantity should really appear in a documenting paper.

Page 3, Line 25 – The reference for Quiquet et al. (2015) seems to be missing.

Page 21, Lines 26 – 28 - The discussion of 'Boreal and temperate forest and deforestation emissions..' is obviously referring to biomass burning but the passage could use a more explicit reference to burning.

Page 21, Line 32 – The word 'that' in 'The CEDS emissions are generally greater that those of...'

Page 23, Line 18 – The NO production from lightning is given as molecules/J, but the assumed energy of a cloud-to-cloud or cloud-to-ground flash is not given so it is

not possible to deduce the NO production per flash. Could the authors include either enough information to calculate the production per flash or the production per flash directly.

Page 29, Line 1 – In Figure 4 is it possible to add the letters of each run that appears in Table S1 to the description of each change? Something like 'New to old J-rates (B to D)'?

Page 31, Line 4 – Page 35, Line 2 – I would suggest either cutting completely or moving to the supplementary material the summary of the sectors, geographic distribution and seasonal cycle of emissions presented here. The figures and tables are based on prescribed emissions that come from independent sources and present information that is relatively well known to anyone with a background in global tropospheric chemistry – the seasonal importance of biomass burning emissions in different regions, for example.

Page 41, Line 13 – Regarding the comparison of dry deposition against field observations (Figure 11), do you compare the ozone flux from the model for a particular vegetation type that is most like the one that dominates the observation site or is the comparison using the flux averaged over the model grid square?

Page 49, Lines 10 - 14 – Looking at Figure 17b, the uncertainties on the tropical tropospheric ozone column defined as two times the variance span quite a large range and easily encompass the model results. But in Figure 16, showing the geographic distribution of the average DJF and JJA columns, large sections of the tropics show the differences as being significant. I know there are different quantities being shown, but the difference between the model and the 2xstdev is quite large. I am also a bit concerned because the upper and lower bounds on the 2xstdev do not seem symmetric around the mean. Particularly the lower bound on the 2xstdev seems to have a variation that is independent of the mean.

Page 50, Line 9 – misplaced bracket in 'MOPITT instrument on board (Terra, Emmons

et al. 2004).'

Page 50, Line 22 – Page 51, Line 2 – I believe problems with the anthropogenic emission estimates of CO has been flagged as a possible source of the general low bias of CO in the northern hemisphere – Miyazaki et al. Atmos. Chem. Phys., 15, doi:10.5194/acp-15-8315-2015, 2015, for example. But that would have been for older emissions inventories and I am not sure how that would apply to the CMIP6 inventory.

Page 53, Lines 1 – 6 - 'Over biomass burning regions... In UKEMS, the anthropogenic emissions are injected on the surface level, so most of the NOx will be trapped in the boundary layer where OMI is less sensitive.' From Page 21 the authors state the biomass burning emissions are injected over the lowest 3 km of the model, which does not seem to agree with what is stated here.

Page 62, Figure 29 – the linear regression from the model is shown in the left-most panel for each of the comparisons, but it would help greatly in the comparison with ACE and MIPAS if the regression for the model was reproduced in the other two panels.

Page 63, Lines 27-28 – It should be '(panel d)' in 'However, the zonal cross section at 23 km ($\sim$ 50 hPa) (panel c) shows...'. More fundamentally, there is no explanation for the red region in panel d.

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-246, 2019.