

## ***Interactive comment on “Evaluating stratospheric ozone and water vapor changes in CMIP6 models from 1850–2100” by James Keeble et al.***

### **Anonymous Referee #1**

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The manuscript presents an analysis of the evolution of ozone and stratospheric water vapour from the pre-industrial to the present-day (2000 – 2014) and out to 2100 from a number of coupled chemistry climate models that were submitted to CMIP6. In addition, the present-day distribution and seasonal cycle of ozone and water vapour from these models are compared to a number of observational datasets. While the factors controlling the projected evolution of ozone and water vapour seen in these simulations are well known, the presentation of CMIP6-era chemistry climate model simulations is an important update of the literature. In particular, the future projections for the new set of CMIP6 scenarios (SSPs) is welcome.

The paper is well written and the presentation of the results is clear so I do not have any significant concerns about the content. I will point out that one difficult aspect of the

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overall presentation is the mixing of models of varying complexity in their representation of atmospheric chemistry. There are five models that include what could be considered a fully prognostic representation of chemistry, with others using specified ozone or linearized chemistry. To complicate the situation further, a couple of the models with specified ozone are closely related to models with prognostic chemistry, having derived ozone from one of the five models with prognostic chemistry in different ways. It makes interpretation of what exactly the multi-model mean represents a bit difficult to fathom. The authors have been generally clear in the description of the models and it is easy to figure out which models contain a full representation of chemistry and which do not. But I would suggest a few minor modifications to help the reader better understand the composition of the multi model ensemble and where the models with prognostic chemistry are significantly different than the other models.

For one, there are a number of models that specify stratospheric ozone using the CMIP6 dataset and yet, see lines 341 – 343 and lines 448-449, some of the models that use the specified CMIP6 ozone show significant differences with each other. Is it possible to include the CMIP6 ozone dataset in a few of the figures comparing the different models? Having the zonal average ozone from CMIP6 dataset shown in Figure 1 and the difference to the multi-model mean in Figure A1, would be very helpful. Perhaps Figure 5 as well?

Secondly, starting at line 538 there is discussion of water vapour in the models, including the behaviour of the CMIP6 multi-model mean that is shown in Figure 12. Given that a number of models do not include a chemical source of water and the fundamentally different behaviour that omitting methane oxidation produces, as seen in Figure 11, I would suggest defining the MMM in Figure 12 as only including those models that include the chemical source of stratospheric water. You really are mixing apples and oranges when you take all ten models that provided water vapour outputs and included them in the MMM. This is much less of a problem for the remaining plots that focus on lower stratospheric water (70 hPa), but for the zonal cross-sections I would suggest

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either a separate plot of the mean of only those models that include CH<sub>4</sub> oxidation or redefining the MMM plot to only include those same models. I would also suggest a similar segregation of models for Figure 17 since the zonal cross-section of PI to PD changes in water vapour will be fundamentally different depending on whether or not the models account for a chemical source of water vapour. Is this approach already used in Figure 18, where only five of the 10 models are used to construct the multi-model means of water vapour shown there?

My other comments are minor and are itemized below.

Lines 205-206: 'form' should be 'from' in 'instead prescribed form the CMIP6 dataset.'

Line 259: The text states that the SAM0-UNICON model uses specified ozone but doesn't say what the source of the data is: 'Stratospheric and tropospheric ozone is prescribed as a monthly mean 3D field with a specified annual cycle.' Is it CMIP6?

Lines 341 – 343: A couple of models are found to have large differences in ozone in the upper stratosphere relative to the multi-model mean, as shown in Figure A1. In particular BCC-ESM1 and FGOALS-g3 are singled out for having much higher concentrations of ozone in the upper stratosphere, but both of these models base their ozone on the CMIP6-specified ozone dataset in some manner. Does this indicate problems with the CMIP6 ozone dataset or problems in how the models used the data?

Lines 632 – 633: 'However, there is poor agreement between the individual CMIP6 models in the pre-industrial and throughout the historical period, with model TCO values spread across a range of ~60 DU.' To make this clearer I would suggest adding a few words along the lines of 'However, there is poor agreement between the individual CMIP6 models for the absolute magnitude of TCO in the...'

Line 1268: The caption on Figure 8 should state that the average is over 90S – 90N.

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