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Geoscientific Model Development Discussions
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Interactive comment on "Description and evaluation of aerosol in UKESM1 and HadGEM3-GC3.1 CMIP6 historical simulations" *by* Jane P. Mulcahy et al.

Anonymous Referee #1

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General comments:

This paper document the GLOMAP aerosol scheme as implemented in the Earth System Model UKESM1 and the corresponding, but less advanced, physical model HadGEM3-GC3.1. It also evaluates the aerosol and cloud droplet properties in the present-day period of the historical simulation of CMIP6 and fixed-SST simulations to several observational datasets. With minor modifications, the paper will be a very useful reference for later studies applying these models to aerosol related questions and for studies analyzing their CMIP6-performances.

Specific comments:

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Discussion paper

- Natural emissions: even though the citations leads to detailed descriptions of the emission algorithms, it would be beneficial for the reader to be served mathematical expressions for more of the emissions to easier see how they vary with climate variables such as temperature and wind.

- BVOC: the models only include SOA production from monoterpenes. Although these emissions are scaled up, they are different in nature compared to other BVOCs. A few sentences about the disadvantages of this simplification would be nice.

- Oxidation: several of the differences in behavior between the two models are linked to their different treatment of the oxidants and the following differences in oxidation close to and away from emission sources. These statements will benefit from map plots showing horizontal distribution of the oxidants and/or horizontal distribution of loss of precursors through the chemical processes.

- Ice crystals: Cloud droplet number concentration is thoroughly evaluated, but what about the ice crystals? If the model does not include aerosol impact on cold clouds, it should be mentioned. If some of the aerosols can act as INP, that should also be described.

- Dust aerosol scheme: please add a sentence explaining why dust is not implemented in the regular aerosol scheme, but needs a single aerosol scheme.

- Cloud droplet number concentration: Can you add some sentences arguing why the satellite datasets are comparable to your model output? Do you use the same criteria for your modeled Nd as in the satellite products (for example cloud fractions > 80 %). With satellites only seeing cloud tops and specific clouds under specific conditions, the model output would be more comparable if the same criteria where used, or if a satellite simulator was applied. If a satellite simulator was applied, it should be mentioned. If not, it should be mentioned that the model output would be more comparable to the satellite products if a satellite simulator was used.

- The conclusion would benefit from adding a few sentences about which improvement that should be made to future model versions.

Technical corrections:

p2, l19: “on which cloud droplets can form” → “on which cloud droplets and ice crystals can form”

p2, l20: “increase anthropogenic emissions leads to increases” → “increase anthropogenic emissions usually leads to increases” (the opposite can occur if it’s already many aerosols and low supersaturation)

p9, Eq. (2): missing two end parentheses.

p11, Table 2: COS is not explained in the text. Please do so.

p11, Table 2: What happens with MSA?

p12, Table 3: be consequent regarding SEC_ORG and Sec_Org

p13, l10: add space after .

p13, l18, add space after .

p13, l24: add space before nm

p20, l15: “historican” → “historical”

p21: Table 4 and Table 5 can be merged for easier comparison of the models by using one type of brackets for UKESM, and another type of brackets for HadGEM

p22, Figure 1. “mg[SO2]m^2” → “mg[SO2]/m^2”

p22, l23: remove . Before “for all years”

p23, Figure 2: Add one column with differences between the models.

p24, Figure 3: Is the regression correct? It does not look correct for some of the figures.

The figure will also be better with partly transparent dots.

p26, Figure 5: “netorks” → “networks”

p33-34, Figure 10 and 11: add arrows on the colorbar (like the other figures in the paper)

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