Interactive comment on "Representation of the Community Earth System Model (CESM1) CAM4-chem within the Chemistry-ClimateModel Initiative (CCMI)" *by* S. Tilmes et al.

Anonymous Referee #2

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Summary: This is a technical paper that summarizes the make-up and performance of the CAM4-chem model for the CCMI simulations. Publication of a paper like this is highly desirable for the CCMI models as it greatly aids the interpretation of these simulations. The paper is well-written. My major comments listed below relate to the model more than the paper; they amount to a minor revision of the paper.

At 40 km, CAM4-chem has an exceptionally low upper lid. There is some evidence in the literature that such a low lid influences stratospheric dynamics and consequently chemistry (although related factors such as differences in model physics between high- and low-top models may also influence this). By comparing CAM4-chem with the high-top version of CESM1, WACCM, it may well be possible to tease out these influences. A

comprehensive discussion of how this is reflected in the CAM4-chem behaviour would be interesting but is beyond the scope of this paper.

The authors note that there are some significant differences in model behaviour between the specified-dynamics and the free-running model. This will be of interest to an ongoing model evaluation activity which focusses on the specified-dynamics runs.

Substantial differences w.r.t. observations are found for the simulation of hydrocarbons. This could be related to the treatment of emissions, i.e. the distribution of generic "NMVOC" emissions across the primary source gases represented in the model. How is this handled here? Do you use any lumping?

Detailed comments:

P3L9: Replace "terrain-following" with "hybrid terrain-following pressure"

P3L11: This difference in vertical resolution is perhaps a little disappointing as it introduces differences into the experiments that are not directly due to the specified dynamics versus free-running experiments.

P3L12: Exactly which fields are being nudged? Do "meteorological fields" include moisture variables? How about differences in orography between the reanalysis grid and the model, which can introduce imbalances into the model? This may not be an issue if MERRA uses the same grid and orography as CAM4-chem.

P4L7ff: Does this error in the formulation of IGW mean that the model gets it right for the wrong reason? Do you have any experience with a version of the model that is not affected by this problem? The improved behaviour despite the above error suggests that either the above is true, or this process may not be important after all. Also this seems to be a new process which affects gyroscopic pumping. Do you need to change the other forms of GWD accordingly, to keep the Brewer-Dobson circulation intact?

P5L16ff: I suspect this is a misinterpretation of the formulation used by Eyring et al., SPARC Newsletter (2013). O_3S is defined as identical to O_3 in the stratosphere but

only subject to loss but not production in the troposphere. That loss must include dry deposition otherwise the straightforward interpretation of O_3S as constituting the stratospheric contribution to O_3 is no longer possible. The word "ozone *chemical* loss rate" used by Eyring et al. (2013) is unfortunate in this regard. Other CCMI modellers will have interpreted this differently. Also aside from the dry deposition issue, what constitutes the correct "chemical loss rate" to apply in this context is subject to an on-going debate. Which rate do you apply?

P6L20: Is that "HadISST2"? Please specify the version.

P8L7: "At 0.04, the dust optical depth is somewhat larger than..."

P8L14ff: This sentence is too convoluted to understand. Please rephrase / clarify.

P10L14f: Are you sure that "all model experiments reproduce observed tropospheric ozone within 20%"? This is a very far-reaching statement. I'd phrase this more carefully.

P11L25: "underestimates"

P12L5: "by up to 5 times in spring": I suggest to replace this phrase by "The model underestimates ethane by up to 80%."

P13L13: "the mid-latitude UTLS"

P13L17: replace "ascribed" with "attributed"

P13L19: replace "great" with "large an"

P16L24: "McFarlane"

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