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Geoscientific Model Development Discussions

Interactive comment on "CESM/CAM5 improvement and application: comparison and evaluation of updated CB05_GE and MOZART-4 gas-phase mechanisms and associated impacts on global air quality and climate" *by* J. He et al.

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Reply to Comments by Reviewer #3

This manuscript documents the comprehensive evaluations and comparisons of two chemistry mechanisms (CB05-GE and MOZART-4) in CESM/CAM5. The topics are well within the scope of GMD. I recommend the acceptance for the publication after following comments are addressed.

Reply:

We thank the reviewer for the positive comments. We have addressed all the comments, please see below our point-by-point reply.

1. Many fields related to chemical species, aerosol species, CCN, clouds are discussed and evaluated in the study. To improve the clarity and readability, the authors may consider to use another way of presentation in section 4. For example, you may consider to add subtitle for different types of gas and aerosol species, e.g., NOx, NOy, O3, HNO3, aerosols (BC, OC, SOA, SO4 and associated precursors), CCN, cloud, radiation.

Reply:

To improve the readability, we added subtitles for evaluation of different types of species and variables in the revised paper.

2. The organization of section 4 is somehow confusing. How about putting all the evaluations in one subsection 4.1 and all the comparisons in the other subsection 4.2. Within each subsection there are different components (e.g., surface, vertical profile, column evaluations..).

Reply:

To avoid confusion, we have split the original Section 4 into Sections 4 and 5 in the revised paper.

Specific comments: 1. Abstract. Line 19, what is CONUS?

Reply:

CONUS is continental U.S. We have added the full name in the Abstract in the revised paper.

2. Abstract. Line 23, why the biogenic emissions are different between the two mechanisms.

Reply:

The different biogenic emissions are mainly due to the different BVOCs mapping for MOZART-4x and CB05_GE. As discussed in Section 2.1 in the paper, both MOZART-4x and CB05_GE include α -pinene (APIN), β -pinene (BPIN), limonene, and ISOP as precursors for biogenic SOA. CB05_GE also includes additional biogenic precursors such as speciated ocimene (OCI), humulene (HUM) and terpinene (TER). However, in MOZART-4x, the species mapping for MEGAN emission calculation is slightly different. For example, α-pinene and other compounds (e.g., α-thujene, p-cymene, and o-cymene) are mapped into APIN; β-pinene and other compounds (e.g., sabinene and camphene) are mapped into BPIN; limonene and other compounds (e.g., phellandrene and terpinene) are mapped into LIMON; myrcene and other compounds (e.g., ocimene) are mapped into MYRC; and beta-caryophyllene and other sesquiterpenes (e.g., humulene and α-bergamotene) are mapped into BCARY. Due to the different mapping for MEGAN species, biogenic emissions between MOZART-4x and CB05_GE are different.

To address the reviewer's comments, we have provided an explanation for different biogenic emissions between MOZART-4x and CB05_GE in the revised paper, see Section 2.1.

3. Page 7198. Line 12, which analysis fields are nudged?

Reply:

The nudged meteorological fields include surface pressure, meridional wind, zonal wind, zonal surface stress, meridional surface stress, snow height, solar flux at surface, soil moisture fraction, surface temperature, temperature, specific humidity, surface geopotential, orography flag, surface water flux, and surface sensible flux. We have included this info in the revised paper, Section 3.1.

4. Page 7201. Line 13-14, please compute PM2.5 accurately since the MAM aerosol

scheme predicts the aerosol size distributions for different aerosol modes.

Reply:

In this work, lognormal size distribution is used for each mode, with prognostic mode dry and wet radius based on number and total dry and wet volume change. The geometric standard deviation (σg) of each mode is prescribed and given in Table S1 in the supplementary material, along with the size range of each mode used in this work.

To address the reviewer's comments, we have calculated PM2.5 concentrations based on prescribed mode dry radius and geometric standard deviation for mode 6 (coarse sea-salt mode) as all other modes are within the diameter $\leq$ 2.5 μm. We have updated results in the revised paper.

5. Page 7203 and follow many pages. There are many "likely". I would like to have more certain assessments.

Reply:

We were trying to include all likely causes for the model performance. However, it is not possible to pin-point exact causes without carrying out a large number of sensitivity simulations, which is beyond the scope of current work and may be a subject of future work. To address the reviewer's comment, we have included some references to support our explanations and speculations in the revised paper.

6. Page 7208. Line 26, change "include" to "included"

Reply:

The suggested change has been made in the revised paper.

7. Page 7211. Please compare your SOA treatment with the Shrivastava et al. (2014) "Global transformation and fate of SOA: Implications of lowvolatility SOA and gasphase fragmentation reactions" in JGR for treatment of SOA in CAM5 and simulation results if possible.

Reply:

Our SOA treatments include volatile SOA formation from anthropogenic VOCs (AVOCs) and biogenic VOCs (BVOCs) and semi volatile SOA from primary organic aerosol (POA). We also implemented functionalization and fragmentation treatments based on Shrivastava et al. (2013). We still use nine volatility bins to represent the aging and gas-particle partitioning of SOA, instead of five volatility bins used in Shrivastava et al. (2015). In addition, compared to the reaction (3) in Shrivastava et al. (2015), we do not have the third term, which denotes additional fragmentation where 10% of the mass results in low carbon number species with very high volatility that is eventually oxidized to CO/CO2 and/or removed by dry deposition. In our model treatment, the remaining mass is assumed to be lost to species with a volatility higher than the volatility values in the VBS structure.

Our model (i.e., MOZART-4x) predicts POA burden of 0.36 Tg, which is about 0.1 Tg lower than Shrivastava et al. (2015), indicating that POA may be too volatile with the current implementation in our model and uncertainties in POA emissions used in our simulations. Our model (i.e., MOZART-4x) predicts SOA burden of 1.82 Tg, which is slightly higher (by 0.05 Tg) than the FragSVSOA case in Shrivastava et al. (2015). This can be attributed to the different emissions used in both work and the fact that more POA is allowed to age to SOA in our model comparing to the FragSVSOA case in Shrivastava et al. (2015).

To address the reviewer's comment, we have provided a description on the SOA treatment in Section 2.2 in the paper. We also compared our POA and SOA burdens with those of Shrivastava et al. (2015).

Reference cited in this reply

Shrivastava, M., Easter, R., Liu, X., Zelenyuk, A., Singh, B., Zhang, K., Ma, P-L, Chand, D., Ghan, S., Jimenez, J.L., Zhang, Q., Fast, J., Rasch, P. and Tiitta, P.: Global transformation and fate of SOA: Implications of low volatility SOA and gas-phase fragmentation

reactions, J. Geophys. Res. Atmos., 120, 4169-4195, doi:10.1002/2014JD022563, 2015.

Interactive comment on Geosci. Model Dev. Discuss., 8, 7189, 2015.