Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC1
https://doi.org/10.5194/gmd-2021-380-RC1, 2022

Comment on gmd-2021-380

Anonymous Referee #1

Referee comment on "Earth system modeling of mercury using CESM2 – Part 1: Atmospheric model CAM6-Chem/Hg v1.0" by Peng Zhang and Yanxu Zhang, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-380-RC1, 2022

It is an interesting work to integrate mercury cycling in the CESM. We recommend minor revision after addressing the following comments.

Abstract, "but they have limited capacity in predicting the future"
It is better to simply explain the reasons why most global atmospheric mercury models have such limitations.

"One advantage of our online model is that the concentrations of Hg oxidants are calculated online."
What is the time resolution of the online Hg oxidants concentrations?

"Aerosols in CAM6-Chem are represented using the four-mode version of the Modal Aerosol Model (MAM4), including sulfate, black carbon, primary organic matter, secondary organic aerosols, sea salt, and mineral dust (Liu et al., 2016). Secondary organic aerosols are treated
using a volatility basis set (VBS) scheme, which is described in detail by Tilmes et al. (2019)."
Aerosols concentrations significantly impact the species transformation of Hg in atmosphere? How are the performances of MAM4 and VBS in predicting the concentrations of aerosols as well as secondary organic aerosols?

"The natural emissions are derived from the average of a 5-year simulation in GEOS-Chem, including geogenic, biomass burning, soil, snow, and vegetation emissions."
Earth system has a natural advantage to couple mercury transfers between different spheres. It is better to calculate the natural emissions in CESM instead of using the results derived from GEOS-CHEM directly.

“The best match with the available observations can be obtained by adjusting the photoreduction rate coefficient”
Please compare the adjusted photoreduction rate coefficients with observations to verify the reasonability of the adjusted results.

“The representation of the main oxidants (e.g., O3 and OH) of Hg0 have been greatly improved and are more comprehensive in the CAM6-Chem, comparing with its predecessors CESM or CCSM (Lamarque et al., 2012; Emmons et al., 2020).”
Briefly describe the results please.

“The global total Hg emissions from all sources are about 7000 Mg a-1, two-thirds of these are natural or legacy emissions. In this study, the rapid re-emission of deposited Hg0 is included in the land emission and the Hg0 dry deposition to the ocean is replaced with the net Hg0 evasion.”
Please introduce how legacy emissions and re-emissions are considered in the method part.

Figure 1, “HOHgI and Hg(OH)2 formed by the oxidation of Hg0 by OH are relatively stable” cannot persuade the readers because the stability of oxidants does not necessarily relate to the significance of pathways. For example, HgBr· is not stable in atmosphere but it is a significantly mid product in the two-step Br oxidation process and Br· is argued as important oxidants. The oxidation pathways are significantly different from previous studies (e.g., Horowitz et al., 2017). Please compare with previous studies and explain the reasons as well as the reasonability of the results. In addition, does the dominant oxidation pathways differ across regions? Please briefly introduce the results?

Figure 4 Please present the uncertainty range of model results.