Response to Reviewer #1 (RC1)

We would like to thank Reviewer 1 for taking the time to carefully read our manuscript and provide feedback. We sincerely appreciate the detailed comments, which have helped us improve the manuscript. Text in blue denotes the reviewer's comments, while text in black denotes our responses. Text in red denotes excerpts from the revised manuscript. The corresponding revisions are shown in the revised manuscript using Track Changes.

Comments (in blue): In this manuscript the authors present a new global ocean mercury model developed within the ocean component of CESM2. There have been a few efforts to develop such ocean mercury numerical models in the past, but this represents a significant step forward because of its coupling to marine ecosystem processes. It also complements existing CESM2 mercury modules focusing on the atmosphere, terrestrial processes, and river transport. The manuscript is well written, clearly organized and presents state-of-the-art description of the processes implemented in this ocean mercury module.

Overall, this work represents a substantial contribution to modeling science within the scope of the journal. The work is of high quality, and I have only a few minor comments and suggestions for the authors to consider.

Response (in black): We sincerely thank the reviewer for the positive and constructive comments. Below we provide point-by-point responses to the comments and indicate the corresponding revisions made in the manuscript.

1. The setup for initial conditions and spin-up is not described in the manuscript (page 3, line 95). Please clarify where do the initial conditions come from and the duration for the spin up. This comes up later in the manuscript (line 263: "the initial condition of the model features relatively high deep-ocean Hg^0"), so providing this context earlier would improve clarity.

Thank you for pointing this out. We have added a description of the model initialization and integration period in Section 2.4:

"*For the simulations in this study, the five ocean Hg tracers were initialized using externally prescribed three-dimensional fields prepared for the MITgcm-Hg configuration described by Zhang et al. (2020). These fields were interpolated onto the POP2 grid and used to initialize the corresponding POP2/Hg tracers. Starting from the prescribed initial fields, POP2/Hg was integrated for 10 years. By the end of the 10-year integration, year-to-year changes in the surface Hg fields had decreased to below 0.1%, suggesting the surface and upper-ocean Hg fields have adjusted to the POP2 circulation and MARBL biogeochemistry. In contrast, the deep-ocean Hg fields were not considered fully equilibrated and remained influenced by the prescribed initial conditions.*"

2. There are many figures presented in the form of maps. It would be helpful to include global mean values (and standard deviations), which could be added as text on the figures, especially for Figures 6–11 (species concentrations, deposition flux).

Thank you for this helpful suggestion. We have added the global mean values and standard deviations directly to the relevant panels in Figures 6 – 11 for the simulated species concentrations and atmospheric forcing fields. The figure captions have also been revised to define these statistics and their units.

3. The authors compare the results of this new ocean model to past modeling work, for example MITgcm-Hg and MERCY v2.0. Including a table summarizing the global oceanic mercury budget across these models would strengthen the comparison.

Thank you for this helpful suggestion. We have added a new table comparing available ocean Hg budget estimates from POP2/Hg, MITgcm-Hg, and ICON-MERCY where directly comparable quantities are available in section 4.1:

Table 2: Comparison of selected ocean Hg inventories and net air–sea exchange in POP2/Hg, MITgcm-Hg, and ICON-MERCY.

Budget	*POP2/Hg*	*MITgcm-Hg*	*ICON-MERCY*
Surface ocean inventory (Gg)	*2.031*	*1.673*	*1.733*
Intermediate ocean inventory (Gg)	*82.423*	*62.089*	*172.194*
Deep ocean inventory (Gg)	*279.045*	*262.898*	*628.597*
Total ocean inventory (Gg)	*363.499*	*326.660*	*802.524*
Net air–sea exchange (Mg yr^{-1}*)*	*−4610*	*−4375*	*−3536*

Negative net air–sea exchange denotes net Hg evasion from the ocean to the atmosphere. For POP2/Hg, 50 and 1000 m denote nominal layer boundaries. A fixed 50 m boundary is used because MLD was not tracked in the present budget diagnostics, whereas the comparison models use MLD where available. The nearest POP2 model level at 985 m is used to represent the nominal 1000 m boundary in the POP2/Hg calculations.

Because the models differ in spatial domain, forcing, initialization, spin-up, riverine inputs, circulation, and biogeochemical representation, we explicitly describe the comparison as a contextual benchmark rather than a controlled model intercomparison. These differences are now noted in the table and accompanying text.

4. Figure 5 typo in title ("reminization rate")

Thank you for identifying this typo. We have corrected "reminization rate" to "remineralization rate" in Figure 5: