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Interactive comment on "A model of mercury cycling and isotopic fractionation in the ocean" *by* David E. Archer and Joel D. Blum

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We first wish to acknowledge, and apologize for, the rough edges of the manuscript. As guessed by reviewer #2, we did submit this in a rush for a deadline. We are grateful for the many constructive comments and suggestions from both reviewers, and anticipate a much-improved manuscript as a result. In spite of the need for further polish, both reviewers found the results in the manuscript to be interesting and useful, which we are glad to hear.

A substantive suggestion from reviewer #1 will require some new simulations to be added to the study, to explore further the impact of reaction pathways on the isotopic composition of Hg species in the ocean. We did a lot of messing around with the model

that we left undocumented in the paper, and acknowledge that this should be added. In particular, we didn't show in a figure the impact of the original scheme, where MMHg photodegrades to Hg2+ directly without homogenizing with the Hg0 reservoir. We will also expand our discussion of the reaction mechanism, which we think supports the reaction pathway that the isotopes seem to require.

The issue of the Hg binding constant to organic carbon continues to be kind of baffling, but we will try harder to understand and explain the difference between our model and others. A difficulty is that the concentration of POC is a poorly-defined thing in the real ocean, grading continuously as it does between fast-sinking particles that actually carry Hg vertically, to suspended particles that apparently exchange mass with the faster-sinking fraction, to the very refractory dissolved organic carbon. We did not see documentation on the POC concentrations used in previous models, so as time ran short we left it as a probable discrepancy in the POC concentrations in the models, and used in our model the Kd value that reproduces the salient result from the other models of how much Hg is bound versus dissolved (about 5-10%), as well as being internally consistent between the sinking fluxes of Hg and POC. In a resubmission, we will dig deeper to resolve or at least more clearly document this issue.

Another substantive addition that we envision is a series of runs with Hg deposition in different oceans, to map out the sensitivity of the deep ocean concentration to the distribution of surface deposition. The reviewers noted that real ocean deposition is not uniform around the world as we set it up in our model, and that other ocean Hg models use detailed deposition maps from atmospheric models. Given the uncertainty in the Hg deposition field through time, it seems like it would be a useful thing to map out the ocean subsurface Hg distribution sensitivity to surface deposition patterns.

We will also improve the comparison of model results with measured species concentration and isotopic signature data (which may motivate adjustment of the anthropogenic Hg flux as noted by reviewer #1), the citations and discussion of previous literature, and the clarity of the text, in response to the many constructive comments

and suggestions from the reviewers.

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