Comments from referee #1:

The paper by Song et al. presents results from an inverse modeling study of global mercury emissions. The data uses a sound modeling approach and a wealth of measurement data. The paper is clearly written and the results significant. The model is used to constrain uncertainties in processes affecting mercury emissions from ocean surfaces as well as emissions from anthropogenic sources. Given the extensive amount of work and the apparent soundness of the results, publication is recommended for ACP.

A weakness of the study is the very modest improvement in model performance due to the inversion as discussed on page 5286. This is not unexpected given the uncertainties in simulating mercury. The last paragraph of the conclusions discusses these issues, but I would recommend an extra sentence or two in the conclusions to connect the discussion in uncertainties with the small increase in model performance. On a minor note, Fig. 2 could benefit from a more complete caption.

We have provided responses to each specific comment below (in blue). Our changes to the original text are shown **in bold** in the quotation.

Authors' response:

In the revised manuscipt, in the conclusion section, we have added an extra sentence on the connection between measurement uncertainties and inverse modeling performance. See Sect. 4: " Our results show that intercomparison errors **(about 10%)** dominate the total observational errors, and thus limit the uncertainty reduction possible by our inverse approach. **Our inversions only lead to moderate reductions of the average NRMSE (Sect. 3.1)**".

We have also added a more self-explanatory caption for Fig. 2. Now its caption is "**Observed and modeled monthly Hg^0 concentrations over the North Atlantic Ocean. The observational data and related references are given in the Supplement. Hg^0_{obs} are the concentrations observed from 19 ship cruises during 1990-2009, whereas Hg^0_{nor} are the concentrations normalized to levels consistent with year 2009. The gray shaded region shows one-sigma error of Hg^0_{nor}, which is composed of observational error, mismatch error, and regression error.**"