We thank the reviewer for the thoughtful and detailed comments. We have revised this manuscript carefully based on the comments. Below we respond to the individual comments:

Reviewer #3, Prof. Daven Henze

Question: The authors have taken some care to respond to the reviewer questions, largely to further explain why they feel the incorporation of HEMCO into the GEOS-Chem adjoint model is a substantial enough update to warrant a publication. They have also further evaluated their update in terms of testing the adjoint gradients with respect to emissions that are now processed by HEMCO, and the performance is perfect (see the new Fig. 6), thus I'm convinced the update works as intended.

That being said, I still have reservations regarding this work as a whole being the basis of a publication, given that it was only upon reading their response to reviewer's question that it became clear to me their updates are only for the tagged-CO simulation and not the full-chemistry simulation. The potential impact and audience is thus smaller. Also, the development of support for MERRA2 meteorology has already been done for non-full-chemistry simulations that have been in place within the standard GEOS-Chem adjoint for up to seven years — that of the CH4 simulation and N2O simulations. They have though made clear that they plan to submit their code updates to the standard adjoint code basis, and perhaps in this process the work can be expanded to support simulation types beyond the tagged-CO.

Answer: Thank the reviewer for the comments! The code update will be submitted to the standard adjoint code basis once the extension to support more simulation types is finished.

Some specific comments on their revisions:

Question: For equations (3) and (4) of the revised manuscript, one shows the sensitivity with respect to a variable 'x' and the other to a variable 'sigma' yet the point here is to provide two different equations (methods) for computing the same sensitivities, which can then be compared as a validation. I thus suggest the nomenclature be adjusted such that the adjoint and finite difference sensitivities are with respect to the same variable (x, or sigma).

Answer: The equations have been revised by using the same variable x.

Question: In the caption for Figure 6, they refer to sensitivities of "global CO concentrations" but I think rather they mean sensitivities of CO in individual grid boxes or columns. In this way one can perform the ensemble of necessary finite difference and adjoint calculations in parallel.

Answer: The finite difference experiments shown in Fig. 6 are performed with the "LFD_GLOB" option (global perturbations) and "LFD=1" (model level 1). Consistent results were obtained by using larger LFD numbers (i.e., higher model levels within the PBL and free troposphere) as shown in new Fig. S10 and S11. The caption of Fig. 6 was updated to clarify that they are the "sensitivities of global CO concentrations (LFD_GLOB and model level 1)".

Question: On line 196 of the revised manuscript, they mention ``experience parameters'' — it's not clear to me what this means. Is this a typo, or could they explain more?

Answer: There are some discrepancies in the treatment of emission data between GC-Adjoint-STD and GC-v12. For example, anthropogenic CO emissions are enhanced by 19% in tagged-CO simulation in GC-Adjoint-STD to account for CO production from anthropogenic VOC. However, the application of this factor is removed in tagged-CO simulation in GC-v12. We have checked the usage of such parameters to ensure the consistency between GC-Adjoint-HEMCO and GC-v12.

As indicated by the reviewer, the description of "experience parameters" in the original version is unclear and we find that it may not be useful to show too many details about the source code. This sentence has thus been deleted in the revision.