Reviewer #1:

Comments:

Zheng et al present an analysis of the global CO budget for 2000–2017, based on satellite retrievals of total column CO, CH_4 and formaldehyde. The study uses a Bayesian inversion approach to optimize CO sources and the sink in a 3-D chemistry-transport model. A detailed analysis of CO budget trends by region is presented, allowing for some conclusions regarding the types of CO sources driving the trends. The authors also compare their results to bottom-up CO emission inventories, other inversion studies as well as surface-based observations.

Summary Statement

CO is an important trace gas, both because of its key role in global atmospheric chemistry and because it is a regulated pollutant; the study topic is thus of high interest. I am not an expert in satellite retrieval approaches, but the good overall agreement of the results with both bottom-up emission inventories and surface-based observations is convincing. The confirmation of the continuing decline of the atmospheric CO burden and CO emissions is a useful result that is well suited for publication in ESSD. The analysis is very thorough, in my opinion, unambiguously identifying a downward trend in anthropogenic CO emissions and also reinforcing earlier work that suggested that biomass burning emissions likely also declined overall.

Response:

We would like to thank the referee for the positive comments on our manuscript. Below is our response to specific comments. The corresponding changes to the initial text are marked in red.

Specific Comments:

Comparison with ground-based observations is an important part of validating the model. I would recommend moving one of the associated figures (e.g., S8) into the main paper to increase its visibility.

Response:

We have moved Figs. S4, S6, and S8 into the main text to make it easier for readers to access them.

While the modeled results agree well with surface CO measurements for most stations (WDCGG comparison), there are many outliers as well. Some discussion of these disagreements (which are quite large for some stations) is needed.

Response:

We have added a discussion of the disagreements in Sect. 3.4 of the revised manuscript as follows.

"The WDCGG sites that show large disagreements are mostly located at coastal terrain areas, where our coarse-resolution model simplifies the coastline and thus cannot resolve the associated meteorology well (e.g., land-sea breeze circulation) (Palau et al., 2005; Ahmadov et al., 2007) and possible local emission sources. Several sites at high northern latitudes also suggest relatively large modelling bias due to the lack of high-quality satellite data as an observational constraint."

Several of the figures and tables (Figs 6, 7bcef, 8, 9, 10, S11, Table S5) do not present uncertainty estimates. These should be added to the figures / tables. For some of the figures (e.g., Fig 8) *perhaps just uncertainties for a subset of the traces (or just one of the traces, such as Inversion 1 in Fig 8) could be added to avoid overloading the figure.*

Response:

We did not add uncertainty error bars in Figs 6, 8, 9, 10, S11, and Table S5 because a variational Bayesian inversion system cannot quantify the uncertainty of the inversion fluxes directly. The estimate of uncertainties would need a Monte Carlo method that is computationally expensive for studying long-term trends. Therefore we used sensitivity tests that varied prior fluxes and observational constraints to assess the uncertainty in this study.

The uncertainties of the trend estimate in Figs. 7bcef are provided in Tables S7 and S10. We did not present them in Fig. 7 because the area of each dot is proportional to annual average emissions, which makes it difficult to add the error bars in the same figure.

Page 8, line 12. I think the value given here for the CO sink trend is wrong – it is inconsistent with what is described in Section 3.2.1 for Inversion 1; also if the sink is declining faster than the source, atmospheric CO would be going up, not down.

Response:

The values given here are correct. The slightly faster-decreasing rate of the CO sink (−11.3±11.0 Tg CO yr^{-2}) than the CO source (−10.3±12.7 Tg CO yr^{-2}) during 2005–2017 would not make the atmospheric CO go up, because the atmospheric CO has kept declining since 2000, and the CO total sink is estimated to be larger than the CO total source during the whole period of 2005–2017.

References

Ahmadov, R., Gerbig, C., Kretschmer, R., Koerner, S., Neininger, B., Dolman, A. J., and Sarrat, C.: Mesoscale covariance of transport and CO_2 fluxes: Evidence from observations and simulations using the WRF-VPRM coupled atmosphere-biosphere model, J. Geophys. Res. Atmos., 112, doi: 10.1029/2007JD008552, 2007.

Palau, J. L., Pérez-Landa, G., Diéguez, J. J., Monter, C., and Millán, M. M.: The importance of meteorological scales to forecast air pollution scenarios on coastal complex terrain, Atmos. Chem. Phys., 5, 2771-2785, doi: 10.5194/acp-5-2771-2005, 2005.