Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC1
https://doi.org/10.5194/acp-2022-303-RC1, 2022

Comment on acp-2022-303

Anonymous Referee #1

Referee comment on "Methane emissions from China: a high-resolution inversion of TROPOMI satellite observations" by Zichong Chen et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-303-RC1, 2022

The manuscript by Chen et al. presents the estimate of methane emissions for 2019 in China by using the TROPOMI data, an inversion method, and GEOS-Chem model simulations. Overall, paper is interesting and could be published after the following concerns are addressed.

- Uncertainty in the abstract and the text. Should the uncertainty range be centered at the best estimate? In some cases, it is; CH4 from coal is 16.6 with uncertainty range of 15.6-17.6. In some case, it is not; total anthropogenic emission is 65 with uncertainty range of 57.7 - 68.4. Please explain why it is so, and how the uncertainty is defined? Is it because the errors from the prior emission are assumed to be log-normal? but this still doesn't explain why in some cases, the best estimate is indeed centered at the uncertainty range.
- The motivation of this paper should be strengthened in the introduction section. It appears that Qu et al (2021) already done global estimate of CH4 emission. How does the results from that paper compare with bottom-up estimate in China and motivate this work? Is it because Qu et al didn't do sector attribution at fine spatial resolution? More articulation above L90 is needed here.
- Bias in boundary conditions (text around L200). While the importance of the boundary conditions is recognized here, does the optimization here attribute the innovation to the emissions within China only or also emissions in elsewhere as well? How are the boundaries defined and will the results be sensitive to the location of boundaries? Methane is long lived, and model-observation difference in CH4 can be attributed to the upper wind regions that are far from the domain of interest, even at the seasonal scale.
- Section 2.4. Does the state vector include sector resolved emissions or simply spatially resolved total emissions? 'total' could be added here. Why number of Gaussian functions is 600 ? Later, 'the inversion optimizes the emissions for each Gaussian function along with 16 boundary conditions ... for a total of .. 616 elements". Should the inversion optimize the state vector x? Consider to add 'in the state vector' at the end of this sentence. Also, should all three Gaussian parameters be optimized, and so there would be 3*600 +16 = 1816 elements? Otherwise, will it be possible that the new source of CH4 in the regions where the prior emissions are low can not be accurately located in the domain with GMM? The fine-resolution TROPOMI data has the potential to accurately identify the local new sources. GMM appears to have the

limitation to locate a new source spatially in areas that the prior emission informs the possibility for large-spatial aggregation. True?

- Aggregation vs. smoothness. From Figure 4c, it appears there are still distinct boundaries in post/prior ratios, which could suggest an artifact as a result of aggregation. I would recommend to plot it with a different color bar that has more smooth transition of the colors and discuss further if there are still distinct boundaries.
- Gaussian representation. 'a mean location, spatial standard deviation, and emission magnitude'. How are those parameters defined by using the a prori emission? What does the mean location mean? Is it emission-weighted geographic center?
- L240. 'the relationship between methane emissions and concentrations in the nested GEOS-Chem simulation is linear'. Is this an assumption? In what time scale? I would think even there is no methane emission in China, global transport would still result in the methane in the air in China.
- Section 2.5. The sectoral attribution. How is the summation matrix W defined? In addition, from what can tell here, it seems that the attribution yields the single scaling factor for the national emission from each sector. In other words, it didn't spatially resolve the scaling factor for each sector in every aggregated area. will it make sense that the sectoral attribution is made in proportion of the relative weights of each sector from the prior emission in every aggregated area? Description of the assumption or reasons for the feasibility of the attribution method is needed here.
- Section 4.1. I could miss something here. but, is there any map showing the change of emission by sector? so it can support that 'our downward correction of .... is driven by the Shanxi province and southwestern China'? This is also relevant to my comments in #4 and #8 as well as the abstract - 'our higher livestock emissions are attributed ... to northern China'. A map showing the posterior/prior ratio for each sector can be useful in the main text.

Minor.

In abstract. mention the year for the prior emission.