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Comment on acp-2021-671

Anonymous Referee #2

Referee comment on "Methane emissions in the United States, Canada, and Mexico: evaluation of national methane emission inventories and 2010–2017 sectoral trends by inverse analysis of in situ (GLOBALVIEWplus CH₄ ObsPack) and satellite (GOSAT) atmospheric observations" by Xiao Lu et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-671-RC2>, 2021

General comments

The authors extend their previous coarse-grid global inversions to a fine-grid regional scale. They optimize methane emissions and 2010-2017 emission trends in North America by in situ (GLOBALVIEWplus CH₄ ObsPack) and satellite (GOSAT) observations, through analytical inversions using log-normal error forms. They point out large emission underestimates in the oil sector by a factor of 2, and a peak of CONUS anthropogenic emissions in 2014. The paper is well written. The methods are clearly described, and the results are well discussed. I support publication, but with a major concern and some minor suggestions.

My major concern is that this study lacks independent evaluation. The authors compare the posterior simulation and prior simulation against the observations used for the inversions, and the improvements against GOSAT are weak. I am curious about the evaluation against the independent dataset, such as TCCON or other local in-situ measurements.

Specific comments and technical corrections

- Row 199: What are the treatments for the initial conditions of the global simulations?
- Row 254: Are the Jacobian matrix for the boundary conditions constructed in the same way as the grid-level emissions?

- Row 297: The error standard deviations for boundary conditions are 10 ppb in the base inversion and 5 ppb in the sensitivity inversions. These are much smaller than the error standard deviations for emissions. How sensitive are the results if applying a larger error standard deviation for boundary conditions?
- Row 317: The observation error standard deviations for in-situ data are $\sim 2\times$ of that for GOSAT, and the total number of observations for in-situ data is $0.4\times$ of that for GOSAT. Readers may be curious about the results if applying two regulation parameters separately to in-situ and GOSAT data.
- Row 417: "This may reflect the underestimation of CO₂ over the Los Angeles Basin". Typo, CH₄ rather than CO₂?

- Row 425: "For GOSAT the improvement is less apparent from the comparison statistics, because the prior simulation already has a low mean bias MB = -0.5 ppb, and the prior RMSE is only 6.9 ppb (which decreases to 6.5 ppb). However, we see from Figure 5 a significant whitening of the noise with reduction of regional-scale biases." This sounds like to contradict itself. It first presents that the regional mean bias of the posterior simulations is 0.6 ppb, larger than the -0.5 ppb in the prior simulations, then indicates that the posterior simulations' regional-scale bias is less than prior simulations in the map.