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Comment on acp-2021-955

Anonymous Referee #1

Referee comment on "The 2019 methane budget and uncertainties at 1° resolution and each country through Bayesian integration Of GOSAT total column methane data and a priori inventory estimates" by John R. Worden et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-955-RC1>, 2022

The manuscript by Worden et al presents a top-down atmospheric inversion for estimating global methane emissions for the year 2019. What is particularly novel about the work is the granularity of detail of the posterior fluxes, which is provided at the country level and for several sectors. The work is intended as a pilot study to support the Paris Agreement Global Stocktake.

While the methods and aim are unique, several assumptions made for treatment of the priors, aggregating sectors, partitioning emissions sectors, and spatial disaggregation to country level are a concern. These assumptions lead to global posterior fluxes that are not consistent with earlier studies. For example, that anthropogenic fossil fuel emissions are 82 +/- 12 Tg CH₄ for 2019 are inconsistent with Saunio et al., 2020 (135, 121-164 TgCH₄), the Global Methane Assessment, Schwietzke et al, 2016, etc., with the range of uncertainty not overlapping with any of these previous studies.

At the country-level, the underestimate in fossil CH₄ emissions is propagated to national scale comparisons between the inversion posterior fluxes and the inventories. The directional changes are inconsistent with findings of Stavert (<https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.15901>) and Deng (<https://essd.copernicus.org/preprints/essd-2021-235/>) and Alvarez (<https://www.science.org/doi/10.1126/science.aar7204>).

To help the reader understand the differences, I would recommend clarifying the following components of the manuscript:

An explanation on how sectors are aggregated is needed, why is agriculture and fire emissions combined, this is not a standard way to show these sectors?

How was the decision made to split the sectors to those listed in Table 3? The partitioning to oil/coal/gas/seeps is likely much more uncertain than what is represented in the Table and overstates the capacity of the inversion system and confidence in the results.

Why is the geologic seepage prior of 32 Tg used? On line 286, 2 Tg are used – but on line 663, 32 Tg is used. This assumption is likely a source of bias in the FF posterior mentioned earlier.

Line 489 says 7 regions, line 494 says 8 regions.

The spatial disaggregation is not clear – the inversion is made at 2x2.5 degrees, using information at 8 regions, then disaggregated to 1x1 degree. These steps are not clear.

A table for the global summary of posterior fluxes is needed.

Which inventory is used in Table 3