

Reply to Referee #1

Overall a very useful paper.

- **Thank you for your review and useful comments. We have revised the manuscript as needed based on your comments.**

It would be useful to compare your GFEI v3 results to other global methane estimates, e.g., EC EDGAR, IEA Global Methane Tracker, both of which you cite. Since GFEI relies substantially on country-level emission reports, please respond to or put in context GMT's statement that ""Methane emissions from the energy sector are about 70% higher than reported in official data." It seems (though I am not a methane measurement expert) that the US EPA continually revises upward methane emission estimates. This is likely the case in other national assessments, e.g., South Africa, and others that you cite.

- **Thank you for these suggestions. We have added comparisons to EDGAR and the Global Methane Tracker and provided some discussion of the potential reasons for the discrepancies in lines 177-185.**

Does the Rocky Mountain Institute GHG mapper (<https://ociplus.rmi.org>) or the Stanford's OPGEE models offer a useful comparison/ (RMI adopts GFEIv2 data).

- **As noted, the methane emissions shown in the RMI OCI+ tool are from GFEI v2 which we do compare to in the manuscript. The emissions intensity metrics in OCI+ and the Stanford OPGEE models are not at the spatial resolution needed for comparison to GFEI as they are focused on estimating field level emissions rather than grid or facility level.**

You use US EPA emission data for abandoned coal mines. Can you make any useful extensions from the US mines to estimate abandoned mine CH₄ rates elsewhere?

- **We did explore this option but decided against it due to the lack of spatial information on abandoned coal mines and the lack of information on flooded status at the time of GFEI v3 completion as this will vastly impact mine emissions. This is stated in Roy et al., but based on your comment, we have also added this explanation to the manuscript in Appendix A. We have also added a note about including this feature in the future if new datasets become available.**

Certain anomalous results in GFEIv3 suggests further discussion, such as Mexico's 2x oil emissions., and Venezuela and Libya (the latter two are explained). Line 191. South Africa's large decrease in GFEIv3 warrants a mention.

- **We note in the manuscript that the changes in Mexico and South Africa are due to the use of the newly submitted reports. Based on your comment, we have added additional explanation in lines 206-215 as to reasons why the new reports have differing emissions from GFEI v2.**

Your highly detailed data is very useful. It is likely beyond your scope, but it would be interesting to see a table of leading countries' emission *rates* per commodity.

- **Thank you for this suggestion. This was similarly assessed in Scarpelli et al., 2022 for GFEI v2. We have added a similar assessment for GFEI v3 as Figure S1 and added description of emissions per commodity in lines 191-194.**

Minor correction: 99.8% vs 99.7% in lines 177 and 204.

- **Thank you. Corrected.**

Excellent work.

Reply to Referee #2

The authors present an update version of the Global Fuel Exploitation Inventory (GFEI v3), integrating 2020 national emissions data and improved spatial allocation datasets. The resulting product (GFEI v3) enhances the fidelity of fossil fuel-related methane emissions at high spatial resolution. The work is timely, methodologically sound, and generally well written. That said, several key clarifications and improvements are recommended as follows.

- **Thank you for your review and suggestions towards clarification and improvement. We have revised the manuscript as needed based on your comments and as noted below.**

1. Table detailing year and source of emissions for each country:

It would be helpful to provide a supplementary table that outlines, for each country (or at least the top 20 emitters), the year of the emission data used, whether it is directly from UNFCCC reporting or derived via IPCC Tier 1 methods, and any national communications or specific reports consulted. This would make the inventory's provenance more transparent and facilitate comparisons with other datasets.

In line 107, the paper states that "Some countries do not submit reports to the UNFCCC, including Iraq and Libya." Please clarify: are Iraq and Libya the only two countries that do not submit any reports? If others also fall into this category (e.g., due to outdated or incomplete submissions), please include in the supplementary table.

- **Thank you for this recommendation. We have now included this as Table S1. We have also clarified the language noted in line 107 to read "..., including Iraq and Libya which are the only countries with GFEI emissions greater than 100 Gg a⁻¹ that fit this description."**

2. Comparison with regional top-down inversions:

The paper would benefit from discussing whether the revisions from GFEI v2 to v3 are consistent with findings from regional inversions that previously used GFEI v2 as the prior. Examples include inversions using TROPOMI or GOSAT. Have those inversions shown discrepancies in regions where GFEI v3 now reports major changes? If yes, does GFEI v3 help reconcile any known discrepancies?

- **We have added discussion of inverse modeling results in our comparison of GFEI v2 and v3 in Section 3 in lines 225-235.**

3. Nature of differences between GFEI v2 and v3 (Bias correction vs. infrastructure updates):

The paper describes both changes in national emissions and changes in spatial allocation. Please clarify: to what extent are the observed differences in emissions between GFEI v2 and v3 attributable to corrections of biases in GFEI v2 (e.g., underreporting in national inventories) versus actual changes in infrastructure (e.g., new coal mines or pipeline expansions)? A brief quantitative or regional breakdown would be useful here.

- **We have added a map to Figure S2 that shows the changes in national emissions between GFEI v2 and v3 that demonstrates where national emissions are the underlying cause of changes between the two versions (as was previously shown in Figure S2). And we have added “Despite these spatial changes, China and India do not show significant changes in total GFEI emissions at the national-scale between GFEI v3 and v2, as shown in Figure S2” to the discussion of changes for large emitters.**

4. Figures 4 and 5 – Visual clarity and explanation:

The red triangles representing super-emitter detections are very small and hard to see. Please enlarge these markers to enhance readability.

- **Done.**

The color of the red triangles overlaps with the color bar used for well density in the background. Consider changing the triangle color or altering the background color scale.

- **There are no red triangles that overlap the well density plots. We have made the keys to the right of the plot larger to make this clearer.**

Figure 4 lacks an explanation for the green dots shown in the bottom panels. What do these represent? Please clarify in the figure caption.

- **We have made the key to the right of the plot larger to make it clearer that the green dots are stations. We have also added “(refineries in pink, processing plants in blue, stations in green, and pipelines as grey lines)” in the description of the figure.**