

Reporting of Gridded (0.1°X0.1°) Methane Emission Data for India to Redefine Global Climate Studies

Mishra et al., ESSD, 2025

Detailed Response to Anonymous Referee #2

We are grateful to the reviewer for their insightful comments and constructive feedback, which have substantially improved the clarity and overall quality of the manuscript. The reviewer's comments are presented below in black, followed by our detailed responses in blue.

RC2: 'Comment on essd-2025-65', Anonymous Referee #2, 24 Dec 2025

Authors have prepared a regional high-resolution gridded methane emission data for 2023 using different cities observation dataset. They have developed different sectoral methane emission over India, which will help decision and policy makers from private and public sector. Indi-Gangetic plane has the highest methane emission and the reasons are understandable. Authors conclude that their method and dataset rectified issue with EDAGR 2023 dataset. Figure 4 is a nice 3D plot to show the difference of earlier studies as compared to their study. They concluded not to ignore the natural methane emission sources like wetlands and solid waste, along with all known emitters like livestock and agriculture. This study will add knowledge to the emission repository for future studies and necessary climate actions. This manuscript presents a timely and policy-relevant high-resolution methane inventory representing Indian methane emission, a major contributor to global CH₄ emissions. Study integrated 25 anthropogenic and natural sources for recent year 2023 is much needed emission work over India and it substantially improves spatial pattern of CH₄ emission. The paper is well written and discussed in an elaborative way, although need some technical corrections.

1. Title is misleading as if it is for multiyear reanalyses dataset. Suggested to add the year "2023".
2. Methodology mainly refers to supplementary material. Instead authors could mention few important pointers like usage of GIS and associated datasets.
3. page 15 line number 323 : 1.8Tg, per yr is missing.
4. Line number 376 : T is missing from This.
5. For wetlands and termites, uncertainty is very large ($\pm 137\%$ and $\pm 161\%$). Briefly describe the sources of such high uncertainties and discuss how this affects the robustness of spatial hotspot identification.
6. Since the paper already cites Janardanan et al. (2024), briefly discuss whether your national totals fall within the range of inversion derived national estimates including this and other such studies.
7. In the abstract, it is mentioned, "However, surprisingly cities exhibit lower CH₄ as compared to other semi-urban/rural regions," which is asserted without explanation. Give some explanation in results and discussion section.
8. Lines 51: "Keeping the diversity of methane sources across the world...", Suggestion: "Given the diversity of methane sources".

9. Line 64: “However, India has not signed the ‘Global Methane Pledge’...”. Consider briefly clarifying why this is relevant to your inventory.
10. Line 72–74: “Although some global inventories have reported CH4 emissions from India... they primarily relied on Tier I top-down approach, resulting in erratic estimations...”. Suggestion: “Erratic” is quite strong and a bit informal. So, I suggest rewriting the sentence.
11. Line 150: “Wetlands have emerged as the second largest source of natural source of CH4 emissions in India...”. Remove repetitive words like ‘source’ and check for others in the entire manuscript.
12. Line 267–269: “Cremation, a practice predominantly associated with the Hindu religion, is another unorganized source...”. Suggestion: You might slightly neutralize the tone by focusing on practice rather than religion: “Traditional cremation practices are another unorganized source of methane emissions...”.
13. Line 375–376: “his newly developed state-of-the-art...” Typing error: “This newly developed state-of-the-art...”. Search the entire manuscript for such typing mistakes.
14. Ensure consistent use of “Tg/yr” and percent symbols and avoid ambiguity between “percent of total India” and “percent of sectoral total”.

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Response:

We sincerely thank the reviewer for their constructive and encouraging feedback on our manuscript. The comments were very helpful in improving the clarity, precision, and scientific depth of the paper. Our detailed responses to individual points are presented below.

1. We appreciate the suggestion. The title has been revised to “Reporting of Gridded (0.1°X0.1°) Methane Emission Dataset for India to Redefine Global Climate Studies; 2023”
2. Thank you for the reviewer’s suggestion, we have thought of it to include the methodology section in the manuscript, however, it makes the article very lengthy. So, we have put all that information in the supplementary file. But now we have added brief overview of the methodology section in the main text.
3. We have modified the unit to Tg/yr.
4. We have now rectified it and checked the whole document to remove similar typographical inconsistencies.
5. The comparatively higher uncertainty associated with certain source categories, particularly wetlands and termites, primarily reflects deficiencies in high-resolution activity data and the limited availability of region-specific and country-wise emission factors. These natural sources are inherently difficult to constrain due to strong spatial and seasonal variability and their dependence on environmental drivers. Although sectoral uncertainties may affect the magnitude of emissions at localized scales, they do not compromise the integrity of the broader spatial patterns. Emission hotspots consistently coincide with regions of intensive agriculture, dense livestock populations, and major waste processing and disposal sites. The gridded allocation framework further reinforces this spatial coherence, as grid cells containing large point sources or high-intensity activities display markedly elevated emissions relative to adjacent cells. Similarly, grids dominated by livestock density and cropland extent are distinctly resolved

in the emission fields. Together, these features demonstrate the spatial robustness of the inventory despite uncertainties in individual source sectors.

6. We sincerely thank the reviewer for this valuable comment. While atmospheric inversion estimates exist for India, they are based on earlier years such as Ganeshan et al (2017), Miller et al (2019), Chandra et al (2021) and Janardan et al (2024) estimated 22 Tg/yr (2015), 35 Tg/yr (2015), 49 Tg/yr (2016), 29.24 Tg/yr (2020), respectively, making direct quantitative comparison with our 2023 bottom-up inventory challenging due to year-specific activity data and emission trends. Nevertheless, our national total of 37.79 Tg yr^{-1} falls comfortably within this observed range of inversion estimates, providing robustness to the inventory's magnitude.
7. We have added an explanation in the results section. It clarifies that lower city-level CH_4 emissions stem mainly from reduced livestock density, smaller cropland area, and improved cooking-fuel use compared to semi-urban and rural regions. The reduction in the major contributing sectors in the cities shifts the hotspots towards rural areas.
8. We have now rewritten this as suggested: "Given the diversity of methane sources across the world..."
9. Thank you for your genuine queries. We must thank the reviewer for letting us explain this. The global methane pledge states that every country should collectively work towards reducing at least 30% of the global anthropogenic methane emissions by 2030, relative to 2020. India hasn't signed this agreement because the Indian methane mission is more of a livelihood emission rather than a luxury emission. Despite this, the Govt of India takes various steps like National Livestock Mission, Gobar-Dhan Scheme, National Biogas and Organic Manure Programme, National Mission for Sustainable Agriculture, National Innovations in Climate Resilient Agriculture, and Swachh Bharat Mission to curb the Indian methane burden. So, to account for the efficacy of these policy interventions, we need to have comprehensive updated sector-specific methane emission data. This inventory will help us keep track of sectoral emissions and our performance compared to other nations in curbing methane pollution.
10. We have replaced the word 'erratic' with 'inconsistent' and rewritten the sentence.
11. We have rewritten this sentence, omitting the repetitive word.
12. We have revised as per the suggestion to "Traditional cremation practices are another unorganized source of methane emissions..."
13. Corrected and verified throughout the manuscript.
14. We have ensured consistent use of Tg/yr and harmonized notation for percentages (distinguishing "% of total national emissions" from "% of sectoral total") throughout the text.