Interactive comment on "CAMS-REG-UNC-v8.1: A detailed uncertainty product for the gridded CAMS-REG-v8.1 emission inventory" by Ingrid Super et al.

We would like to thank the reviewers for their interest in our study and for the time they spend to comment on our work. The review comments have been helpful in reflecting on our work and pointing out parts that required further improvements and clarification. Below we address specific issues mentioned by the reviewers point by point. The manuscript has been updated accordingly (line numbers refer to the track-changes manuscript).

Anonymous Referee #1, 27 Apr 2026

This paper presents a methodology to quantify uncertainties in the CAMS-REG European emission inventory, providing both country-level and gridded uncertainty estimates for greenhouse gases and air pollutants to support inverse modelling and emission verification.

The paper is interesting, well written, and cover a much needed aspect of emission inventories preparation.

We thank the reviewer for this positive note.

However, I have some points I would like to see covered and improved before possible publication

- Table 1: why is this table only available for CO2 and CH4? Could you extend this to cover also air pollutants?

We have now included the full list of air pollutants in Table 1.

- Table 2: please better explain how these values are derived

In Table 2 we list as much as possible references to uncertainty estimates in the base data used for our proxies. However, a lot of expert judgement is needed, as information on data accuracy is often lacking or data are further processed to improve the representativeness. For clarity, we have now included information on the base dataset and added some more explanation where we use expert judgement.

- section 2.3. I re-read few times this section, but I have to say it's quite complex, and I would like to see this improved, for better clarity. I.e., could you describe the steps in a workflow/graph? There are some efforts in this direction (as Figure 2) but this section 2.3 should be improved, as it is the core of the paper, and at the moment is quite complex to follow

- similar to section 2.3, also section 2.4 should be improved, for better clarity

We thank the reviewer for this comment. We have asked a colleague not involved in this work to review sections 2.3 and 2.4 and make suggestions to improve the readability. We added an introductory paragraph to both sections, the order has been changed and the caption of Figure 1 (which shows the workflow presented in section 2.3) was updated to more clearly link it to section 2.3.

- Figure 2: also I found this Figure complex, and I cannot easily link it to the rest of the text...could you please improve its readability?

We have increased the readability of Figure 2 and updated the text in section 2.4.

- Table 3 shows optimized and non-optimized uncertainties. To my knowledge, the optimized uncertainties values you get are quite low...are these values strongly affected by the uncertainties values you use as input, and if yes, did you implement a proper sensitivity analysis? Also, as these optimized values are quite small...are there other uncertainty source that should be considered and are not considered in your modelling, to fully define emission uncertainties? please specify

Firstly, we want to point out that the 'Optimized' and 'Non-optimized' columns refer to different country groups. The optimized values are for countries with detailed emission reporting. The non-optimized values represent countries without detailed emission reporting. As pointed out by reviewer 2 this was not quite clear from the text and we have added this explicitly in lines 350-352. This means the two columns cannot be compared directly.

The 'Optimized' values presented in Table 3 should indeed reflect the uncertainty input. For CO_2 the gridded uncertainties are dominated by the proxy uncertainties from Table 2, whereas for the other trace gases it is

mostly a combination of country-level uncertainties and proxy uncertainties. For most countries and pollutants the optimization increases these gridded uncertainties by a few percent (see Figure 6), except for CO_2. That the values are perhaps lower than expected based on previous studies could be for several reasons:

- Other studies often use a point-wise comparison of multiple gridded datasets to estimate uncertainties, which is more sensitive to major outliers. Moreover, the spatial error correlation lengths allow us to keep the gridded uncertainties lower when matching them to the country-level uncertainties. These points are discussed in lines 436-440.
- The errors are propagated assuming no error correlations exist anywhere in our dataset (except for the spatial correlations). This assumption may not hold and incorporating error correlations, for example between sectors, may increase the gridded uncertainties, as also mentioned in lines 462-468.
- There may be other sources of uncertainty that we didn't take into account because we cannot quantify them, such as sources completely missing from the country reports or being double-counted, as mentioned in lines 113-115.

- Section 5 (data availability)... I checked the provided data...I think, to facilitate their use, on top of the usual CAMS-REG format for the data, one should provide a gridded uncertainty data (or at least a python code to convert the CAMS-REG format to a more simple gridded uncertainties field).

We thank the reviewer for this suggestion. However, the current CAMS-REG data format is chosen to limit the file size. Given that the country code is an essential piece of information for applying the data, and at borders therefore grid cells often occur twice, using a simple grid would create many layers (per country, per sector, per species) with mostly zeros or blanks. The current CAMS-REG format is widely used by modelling groups, who have developed their own way of dealing with the current data format. We believe that the most likely users of our data already have the tools to process this dataset and therefore changing the format would create more problems for modellers than it would solve. Each user will require its own format/style and we cannot accommodate all of them.

Anonymous Referee #2, 12 May 2026

The manuscript is very well written, clear, concise, and interesting to read, and the resulting uncertainty estimates for gridded CAMS-REG emission inventories represent a useful and relevant product for the community.

We thank the reviewer for these kind words.

I provide below a few general comments and suggestions that I hope will help further strengthen the manuscript.

General comments:

The manuscript would benefit from a clearer explanation of how the present work relates to preceding studies. Which assumptions are retained across versions, and which have been modified? A concise overview table or a dediacated section could be helpful in clarifying these differences.

For users familiar with previous versions, a more direct one-to-one comparison would also be valuable. In particular, it would be interesting to understand how the estimated uncertainties are affected by the differences in the approaches between versions.

We thank the reviewer for this valuable comment. We added a section 2.5 highlighting the differences of this work to the two previous versions, including a table with all relevant details. A quantitative comparison of the versions is too complex, given the different output metrics, formats and resolutions. However, we indicate in section 2.5 that each version has received updates based on improved prior knowledge and new insights and is therefore expected to outperform the previous version(s).

The optimization approach plays a central role in "correcting" the prior gridded uncertainties. While I consider the approach itself to be sound and innovative, it may carry a risk of compensating, in some cases, for errors or biases in the prior gridded uncertainty data. It would be useful if the authors could reflect on this potential limitation in the discussion section.

In a previous version of our uncertainties dataset we separated the country-level emission uncertainties and uncertainties in the spatial allocation. However, users struggled to combined the two and the results were

ambiguous and inconsistent. Therefore, the optimization approach is merely developed to facilitate easy implementation of the data by providing just one single dataset.

Although the method is statistically sound, it tweaks the input data that we gathered and specified with great care, and therefore it is more difficult to understand the physical meaning of the output of the optimization. Nevertheless, the scaling factors shown in Figure 6 only increase the gridded emissions by a few percent in most cases (except for CO2). We accept this change, despite the risk of overcompensating, given the large uncertainties in the input and methodology and the fact that it facilitates the use of our data. We have added a few lines to the discussion to point this out (lines 469-473).

Specific comments:

The authors might consider complementing the boxplots with violin plots. This would provide additional information on the shape of the distributions, including skewness or potential multimodality. This would be particularly interesting for Figure 4, where the boxplots for several sectors appear to be rather skewed.

We replaced all box plots in the manuscript with violin plots, but keeping the inter-quartile range and median values as horizontal lines, similar to the box plots.

Table 3 is not fully clear and is not discussed in sufficient detail in the text. On first reading, I was confused because I assumed that the two columns referred to the same set of countries, and therefore wondered why the non-optimized CO2 values were higher than the optimized values, even though Figure 6 shows scaling factors mostly below 1. However, if I understand correctly, the two columns refer to distinct groups of countries. This should be clarified in the table caption and/or the main text.

We thank the reviewer for pointing this out. We have added a paragraph explaining Table 4 (Table 3 in the previous version) in more detail, specifically mentioning the different country groups presented in the two columns, and explaining the difference in values (lines 350-353).

Figure 5: I find the logarithmic colour scale, especially for the relative uncertainties, somewhat difficult to read. Adding more tick labels could improve readability, for example at 0.2, 0.4, ...

We agree with the reviewer that the colour bars are unclear and we added more tick labels to Figure 5.

Technical corrections:

Add hyperlinks to references

We are not quite sure what the reviewer means with this: either linking the in-text citations to the reference list or adding URLs to the reference list? The first will be done by the journal editors, the second is already done where possible.

Line 358 typo: if -> is

We corrected this typo.