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comment**

Interactive comment on "Uncertainty analysis of a European high-resolution emission inventory of CO$_2$ and CO to support inverse modelling and network design" *by* Ingrid Super et al.

Anonymous Referee #2

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This manuscript presents an assessment of the uncertainties in high-resolution emission inventories of CO2 and CO in 14 European countries. The uncertainties present in various underlying parameters of the inventories (e.g., absolute uncertainties in reported emissions, emission factors, spatial proxies, temporal profiles) are propagated using a well-described Monte Carlo simulation routine. The uncertainties are tracked to assess the importance of specific source sectors in introducing large uncertainties on both absolute and relative bases. Several factors are found to be playing an important role in contributing to the final emission uncertainties. For instance, spatial disaggregation of the emissions at a high spatial resolution results in large uncertainties at the local/city scale, which has important implications for inverse modeling studies operat-

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ing within these smaller spatial domains. The authors find that because certain sectors with large overall contribution of CO_2 and CO emissions are well-constrained (e.g., industrial sector in the Paris metro area), the relative uncertainties in these locations are far smaller than those in the immediate rural surroundings. Thus, future efforts to reduce absolute emissions of CO_2 and CO may use the absolute uncertainties presented in this study to identify a network of key target areas/sectors.

Overall, I find this manuscript well-written. The methods are presented in sufficient detail that one could reproduce them. The methods section lacks some quality assurance, as I have described in my first major comment. The results are presented in an organized fashion, and the interpretations and conclusions are generally well-reasoned. My second major comment has to do with the framing of these interpretations with respect to observation-based literature, especially since the authors mention a motivation for this study is to facilitate inter-comparison of modeled and observed greenhouse gas concentrations. Once the authors have addressed these comments adequately, the manuscript should be ready for publication in ACP. In addition to my two major comments, I list several minor comments that are mostly typographical errors and/or suggestions to improve presentation of figures and tables.

Major comments:

1. A rationale for number of Monte Carlo (MC) simulations should be provided. For e.g., a plot with some metric of quality of results (total residual, total error, full-width half maximums of the distributions showed in Fig. 7, etc.) versus number of MC runs. I'd expect such a plot to have an exponential decay with respect to increasing MC runs, which would then help justify the choice of N = 500.

2. I think the presentation of the results could be better framed with respect to other literature. For instance, the authors show that the spread in their modeled CO_2 and CO concentrations reduces over distances of 5–40 km from the source categories (Figures 10 and 11). How does this length-scale compare with other

studies? Are there any monitoring studies that have shown similar fall-off length-scales? To say that road transport affects CO concentration as far as 40 km downwind seems excessive, if one were to compare it to, say, Figure 4A from Canagaratna et al.'s mobile monitoring study.

Minor comments:

1. L24: I suggest using "abundant", instead of "important". In terms of warming potential, there are other gases more important than CO2 (e.g., CH4).

2. L36: "report", not "reported".

3. L69: "atmospheric", not "atmospherics".

4. L64-65: "in contrast, if . . . are needed." This sentence is unclear. What is "prior" referring to? Please reword.

5. L76-77: not sure what "European zoom region" means. Please clarify.

6. L81: suggest replacing "time profiles" with "temporal profiles", or "diurnal profiles".

7. L81-83: question 3 is somewhat unclear. It could be reworded for clarity, but also the motivation for this question was not set up in the introduction. This makes this question feel abruptly added.

8. L86: is "partitioning" the right word? I suggest using "apportionment", instead.

9. Table 1: for consistency with first usage in L26, please continue with the "FFCO", "FFCO2" naming conventions. The acronyms FF and BF should be declared in the Table caption. Also, is there a specific reason to use three-letter country codes, instead of simply country names?

10. L103: "gap-filled" (should be hyphenated).

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11. L103: suggest replacing "data was gap filled" with something more informative of which attributes of the dataset were missing, and how they were filled (i.e., with NaNs, or geospatial interpolated, etc.).

12. L105: acronym "AIS" not defined.

13. L108: comma is used instead of period.

14. L109: acronym "GNFR" not defined, and is also used in Table 2 without definition.

15. Figure 1: could the authors add a few landmarks or identify a few of the visible hotspots in these maps e.g., Paris? It'd be helpful for a reader not familiar with the placement of major urban areas of Europe.

16. L148: which "differences" are being referred to in this sentence? Differences in uncertainties, I assume? Should be clarified.

17. Figures 2 and 3: the gridlines need to match the category labels. The current version of this figure is difficult to read easily.

18. L294-296: This sentence is confusing. Here is how I would calculate the "uncertainty in the total emissions": a) take the standard deviations of emissions from each sector (i.e., standard deviation of each box in Figure 7-left), b) calculate the average of the standard deviations from (a), and c) report this average from (b) as "uncertainty in total emissions". However, it seems the authors have used a different approach: a) take the standard deviations of emissions from each sector (i.e., standard deviation of each box in Figure 7-left), b) calculate the STANDARD DEVIATION of the standard deviations from (a), and c) report this STANDARD DEVIATION from (b) as "uncertainty in total emissions". Is this correct? If yes, this would not be the "uncertainty in total emissions", but rather would be an "uncertainty of the uncertainty in total emissions". Please justify/clarify/correct in the manuscript accordingly.

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19. Figures 8, 9, and 16: As I indicated in my initial review prior to posting on ACPD, the legend needs to be reversed to be consistent with the order of stacking.

20. L322-323: "Overall, the differences between countries are relatively small (Figure 9, right panel)." Instead of using a qualitative term like "relatively small", why not report the total uncertainty as done for Figure 7?

21. L339: "For CO2 (left panel) we see a concentration of about ..." should be changed to "For CO2 (left panel), we see a spread in concentration of about ..." There is no information in Figure 10 about the absolute CO2 concentrations, so seeing a concentration of 3 ppm anywhere in ambient air would be impossible. A related suggestion is to plot the absolute numbers on the right axis, to get a better sense of the absolute concentrations (especially for CO).

22. L343: what does "atmospheric signal" mean? Why not just say "modeled spread in concentration"?

23. Figures 10 and 11: the x-axis labels are unevenly spaced. It is definitely not linear, but it doesn't seem log-spaced either. Please correct/clarify in Figure caption.

24. Figure 12: Please describe what the grey lines represent in the caption.

25. L397: "in inverse modeling, often ... transport". It'd be good to include a couple of references to support this statement.

26. Figure 13: I know that time profiles used for modeling CO2 and CO emissions are the same, but it'd be good to rename the y-axis label to "normalized spread in CO2 and CO emissions", and remind the reader of this very briefly in the caption.

27. L447: "big cities like Paris, Berlin, and Brussels". I assume this is about the CO, and not the CO2 map? It'd help to point to these cities in Figure 15.

28. L528: no need to define the acronym LTO, if it is only used once.

Reference(s):

Canagaratna, M. R.; Onasch, T. B.; Wood, E. C.; Herndon, S. C.; Jayne, J. T.; Cross, E. S.; Miake-Lye, R. C.; Kolb, C. E.; Worsnop, D. R. Evolution of vehicle exhaust particles in the atmosphere. J. Air Waste Manag. Assoc. 2010, 60 (10), 1192–1203.