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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantitative evaluation of the uncertainty sources for the modeling of atmospheric CO_2 concentration within and in the vicinity of Paris city" *by* Jinghui Lian et al.

Anonymous Referee #3

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General Comments: This study by Lian et al., 2020 attempts to identify and quantify significant sources of errors that can hinder the accurate estimation of urban-scale emissions. The objective of this study, as claimed by the authors, also includes demonstrating how these diagnostics can be used for inverse modelling studies. An ensemble of WRF-Chem simulations are performed, varying emission inventories (one month of simulations), PBL schemes and urban canopy schemes (one year of simulations), and boundary conditions (one year of simulations). The topic is fascinating and is essential to investigate the how sensitive is the emission estimate to the different components of the transport mechanisms (simulated by the model), flux variations, and assumptions/methods employed. This is a well-written manuscript with clearly described meth-

ods and results arranged in a logical order, which made the manuscript easy to follow. The conclusions drawn, based on their analyses, are reasonable and are applicable to those working on city-scale and mesoscale inversions of CO2 using WRF-Chem.

The study in this present form, however, fails to justify the title. Though the study considered an ensemble of simulations and subsequent analyses, it is still insufficient to make a quantitative estimation/evaluation of sources of errors in CO2 simulations which is adequate to the broad spectrum of inverse modelling studies. I'd instead consider it as a study on diagnosing the effect of vertical mixing (PBL schemes), specific modelling criteria (urban schemes) as well as boundary conditions in city-scale modelling, in addition to assessing the sensitivity of simulations to the emission patterns. I believe that the title can be reworked accordingly to present the study appropriately. Additionally, some other sections require more clarification, modification, and further analysis, as mentioned below. Thus, I would recommend a major revision before considering for publication in ACP.

Though it is mentioned as one of the objectives, I don't see that the study has addressed the question to what extent or how the model-measurement error can be reduced. This is a major concern of mine. I'd consider that the authors could devise efficient analysis strategies to address this, given the availability of measurements from 6 +2 sites and ensemble of simulations. An adequate diagnosis of model-measurement mismatches is missing, which is a weakness of this manuscript. A discussion on how the diagnostic results can be used for the betterment of inversion studies is vaguely articulated in the manuscript. All the guidelines for the data selection put forward by the study (such as discard data with high model-data misfits, use only afternoon values; test the influence of boundary conditions) is already known to the community and currently practised in inverse model calculations. I would suggest authors avoid the above statement of objective or revise thoroughly while incorporating additional analysis to explain the novelty of their findings.

Specific Comments: Fig. 2. For Line style descriptions, please use another colour (e.g.

black) than those used as line colours. Blue is already used for “Total”. I had a hard time to understand. Also, I’d suggest you remove (c) and (d) and include AirParif (daily) and Constant in (a) and (b).

Differences between CAMS and CarbonTracker at the four lateral boundaries: Why are there substantial differences between daytime and nighttime in East boundaries, sometimes even in opposite phases (Fig. 3b)? Please explain.

Evaluation with in situ observations: I am not very convinced with the usage of KNN method? How is the outlier fraction calculated? How sensitive is the filter size in another outlier fraction? What are the criteria for the choice of 0.1 in this case? Given that outliers are removed, why the model-observation mismatch is this high (Fig. 4)? How can these mismatches be reduced? How about background sites in terms of evaluation? In addition to reporting the mismatches, I’d suggest the authors explain the reasons for these large deviations from observations. This is critical as I also see unexpectedly significant model-measurement differences in diurnal averages. Have authors checked different choice of physics/dynamics schemes or other parameters available in WRF-Chem to reduce this mismatch?

Sect. 3.2.1 “modeled value (green line in Figure 6) gets somewhat closer to the observation” In Fig. 6, the blue curve represents constant emissions. Please check. Also please indicate the season (or January) in the figure caption. The simulations (BEP_MYJ_CON) reproduce the observed patterns better than other simulations; however, not in magnitude. So please rephrase the sentence accordingly: “modeled value (green line in Figure 6) gets somewhat closer to the observation”. Also, I am happy to note that the authors demonstrate the effect of emission trend and atmospheric vertical mixing here. Please comment on the effect of boundary conditions (though I expect it to be minimal by looking at the patterns in BEP_MYJ_CON).

PBLH and vertical distribution of the modelled CO2 (BEP_MYJ): It is not clear to me why authors have mentioned Nielsen-Gammon et al., 2008 for PBLH estimation. What

extent the MYJ scheme and Nielsen-Gammon et al., 2008 differ in deriving the PBLH? If different, a comparison plot will be helpful here. I am a bit surprised with the high PBL values in winter (initial half-month) over Paris. Do authors look at the PBL measurements (e.g. lidar measurements)? Fig. 7 is confusing as the 34-m AGL curves have nothing to do with the left Y-axis values. I would suggest authors separate these two curves (magenta and pink) from this and make an independent plot along with PBLH.

Sect. 4: Please see my comments above (w.r.t title) and refine this section thoroughly.

Minor comments: Page 7, “from 18 pm to 22 pm)” Please change to 18:00 UTC to 22:00 UTC.

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