

Atmos. Chem. Phys. Discuss., referee comment RC1
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Comment on acp-2020-1174

Anonymous Referee #1

Referee comment on "The CO₂ integral emission by the megacity of St Petersburg as quantified from ground-based FTIR measurements combined with dispersion modelling" by Dmitry V. Ionov et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-1174-RC1>, 2021

Review of ``The CO₂ integral emission by the megacity of St. Petersburg as quantified from ground-based FTIR measurements combined with dispersion modelling'' (acp-2020-1174)

The manuscript presents the results of two measurement campaigns during the spring of 2019 and 2020 when portable FTIR instruments and an in-situ instrument were used to measure CO₂ mixing ratios in the vicinity of St Petersburg. Using ODIAC as a first guess for CO₂ emissions, the authors run HYSPLIT dispersion model to predict surface concentrations and differential total column mixing ratios of CO₂ at the measurement sites . By comparing the measurements and dispersion model results the authors come up with new estimates of CO₂ emissions from St Petersburg region.

Although the analysis is potentially interesting and provides methods to better constrain urban emissions, the science is not properly communicated. The manuscript is not well structured and the methods are not clearly outlined and the descriptions are not sufficient to reproduce the science. Methods and Results need to be clearly outlined in a proper logical order. In addition each step should be explained in more details in order to be understandable by the audience.

Here are my comments that I think would help improve the manuscript:

General structural comments:

■

There are no clear distinction between the methods, results and discussion sections in the manuscript. The manuscript should be reorganized in order to better guide the audience through the entire analysis step by step.

■

The introduction doesn't clearly outline the scope of the work. The bullet points at the end need to be expanded in more details. All the subsequent sections and subsections that follow the introduction should be outlined in the introduction in the same order.

■

The authors should not assume that the readers are familiar with the previous work neither they should expect them to read other manuscripts to understand the scope or the methods used in the current study. While citation to the earlier study (Makarova et al. (2020)) is encouraged in moderation, methods should be briefly explained in the current manuscript as well.

Scientific comments:

■

It is mentioned that during the 2019 campaign two FTIR instruments were used whereas only one instrument was deployed during the 2020 campaign. There are two questions regarding this: 1) Where were the locations of the two instruments in 2019? If there's more than one configuration, clearly outline the locations at each specific day. Presenting the measurement locations on the map is encouraged. 2) How did you estimate ΔCO_2 in 2020 by using only one instrument. Did you move the instrument within one day? If yes, what time? Outline clearly maybe in a table. You should keep in mind that due to the air mass dependencies the diurnal differences do not necessarily reflect changes in the emissions. So knowing the measurement times is critical.

■

Which retrieval algorithm was used for analyzing the FTIR spectra?

■

Could you show the timeseries of XCO_2 or ΔCO_2 showing FTIR measurements for a typical day or the entire period of measurements? This would help the readers understand the daily variations and enhancements better.

■

How the two FTIR instruments compare to each other when measuring side by side?
How are you accounting for potential instrument biases?

■

You mentioned you have excluded a pixel from ODIAC priors because the emissions seemed to be an outlier. What if it's the emissions from a power plant(s) that was misattributed to a wrong location? It is expected that industrial sources and power plants stand out as they are point sources with significant amount of emissions. If you any valid reason to modify emissions from that pixel you should clearly state that you are not using ODIAC but a modified version of ODIAC.

■

For comparisons of in-situ measurements and HYSPLIT model results you are using a fixed background of 415 ppm. Given the day to day variations in the CO₂ levels it's not very reasonable to use a fixed value for the entire period of the analysis unless you bring proof that this was the case for St Petersburg during the campaign.

■

It will be useful if you also plot the one on one curve for HYSPLIT vs in-situ measurements from which you found out a scaling factor.

■

Please describe in details how did you estimate fluxes using the mass balance method. Bring equations if necessary.

■

How are you computing column ΔCO_2 using HYSPLIT? Do you take an integral over the vertical layers of 1m-1500m?

Detailed comments:

- Line 26: From the value in brackets I imply that emission estimates during the lockdown period was higher than the rest but the last sentence of abstract is suggesting there was a 8% decrease. Please clarify!
- Line 42: Please consider adding a proper citation.
- Line 43: Do you mean anthropogenic CO₂ emissions? Also having total fossil fuel consumption is not enough to estimate anthropogenic emissions. There are emissions

associated with land use change, agriculture and other industries such as cement production.

- Line 77 and 78: Please bring proper citations for both official and unofficial population estimates.
- Line 88: How much is the contribution from transport in St Petersburg? It's important since you are mentioning transport emission changes during lock down period later in the text.
- Line 113: As mentioned earlier please briefly describe the campaign in a separate paragraph don't assume audience have read the other paper. Then state what are the differences/additions that you are making in this study compared to the earlier one. Also it might be useful to dedicate a separate paragraph about the instrument. Briefly explain how it works and how spectra are retrieved. Better to move this part to the methods section (that doesn't exist at the moment).
- Line 150: Please describe in more details how you estimate ΔCO_2 . What's the averaging interval? Do you filter the data in anyway. etc. This will also go to your methods section. Also it is better to bring the comparisons with other cities to the discussion/conclusion section.
- Line 155: what do you mean by geometry of the field experiment? You mean topography?
- Line 161: you mention here that the resolution of ODIAC is 1 km by 1 km. Later in the text you mention 0.93 by 0.46 km. This might confuse the audience please clarify.
- Line 213: Is this ODIAC value after you removed the pixel with 7000 kt/km²? If that's the case as mentioned above please clearly indicate it's not the original ODIAC value. If we add 7000 to this value then the model-measurement agreement might improve.
- Line 226: what is the time period of field observations?
- Line 236: What is one observational series?
- Line 251. The sentence is unclear. Please consider rewording.
- Line 294: The sentence is unclear. Please consider rewording or adding more explanation.
- Line 302: Please specify in detail which days were excluded from the analysis and how many days are used after the exclusion. As mentioned earlier a table would be helpful.
- Line 359: Please explain in more details why that's the case. From what I understand the in-situ measurement site is in a fairly remote location but the FTIRs have been deployed in the city centre and closer to large sources. So there are other variables that might play a role here!
- Figure 1 and 8: Please add latitude and longitude coordinates to the map.
- Figure 3: Please add latitude and longitude coordinates to the bottom map.
- Figure 4 and 8: Please specify the averaging interval.
- Figure 6: Please add latitude and longitude coordinates to the map. Also please specify the location of upwind instrument for 2019. It would also be helpful to specify the dates at each location.
- Figure 7: Are the ODIAC area flux values shown the average over the entire domain or the average along the HYSPLIT back-trajectory?