Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2021-808

Anonymous Referee #2

Referee comment on "Assessing vehicle fuel efficiency using a dense network of CO_2 observations" by Helen L. Fitzmaurice et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-808-RC2, 2021

General comments:

Fitzmaurice et al. al present a well-structured manuscript discussing the use of novel data collected in the atmospheric high-density network BEACO2N in combination with an inverse modelling framework to assess local highway CO2 emissions. They compare the CO2 emissions per vehicle kilometer travelled on the highway as derived from bottom-up modelling and their inverse framework. They find good agreement for many periods, but also noticeable deviations especially in periods with congestion. The daily changes in emissions are also tracked by both approaches and the study suggests that future emission trends due to local mitigation actions in the transport sector could be tracked.

The issue of mitigating greenhouse gas emissions is very timely and especially GHG emissions at urban scales have been moving into the focus of the atmospheric science community in recent years. This study is a nice addition and demonstrate novel capabilities to retrieve emission rate estimates at highly localized scale from a network of lower-cost sensors. Both quality and topic of the study are suitable for publication in ACP. However, there are quite a few minor technical issues and clarifications that need to be addressed before this manuscript should be accepted.

Air quality:

The introduction and discussion sections include paragraphs on the importance of air-quality proxies from traffic. However, the study itself only models (emission modelling)

and estimates (inverse modelling) CO2 emissions. No AQ data is shown, so the discussion section feels speculative. Suggestion to either include some data on AQ/CO2 ratios collected during the period covered in this inversion or moving this into an outlook session to clarify that the AQ statements are not direct results from this work, but extrapolations.

Non-highway sources:

The impact of non-highway sources needs to be addressed in a (little bit) more detail. The fact that is contributes ca. 12% on average is promising, but not sufficient.

Are those sources/sinks acting constantly? If they could vary on the short-term, i.e. with a very strong contribution during rush hours and no contribution any other time they could still influence e.g. the rush hour findings? (Unlikely but should be explicitly ruled out).

Bibliography:

For some studies the author's first name are left our, sometimes they are abbreviated, sometimes even middle names are included. Citations should follow one consistent style, if possible.

Also, not all references fulfill the minimum criteria, e.g.:

Boswell and Jacobson 2019: Where can this report be found?

Delaria et al. 2021 lacks information on where it was published. Please add journal name, issue, etc. or at least the DOI.

Minor and technical corrections:

L11: This statement is legitimate for the US, but it is unclear of transportation is also the largest CO2 source in developing economies, where urban centres also house large industrial and manufacturing districts.

L32: (and throughout the manuscript): The citation style is very inconsistent. For some studies the author's first name are left our, sometimes they are abbreviated, sometimes even middle names are included. Citations should follow one consistent style, if possible. See general comments.

L38/L40: The authors state per capita emissions from vehicle have increased or stayed constant, but then cite a study that reports a 2% decrease. Please clarify if -2% is considered constant here. Or change to 'increased or stayed nearly constant'

L90: Why was a stretch of highway selected in the region with the lowest low-cost sensor density?

Looking at figure 1 (left) most parts of the bay area have more sensors per km2.

L101/102: the authors state that an accuracy of 1.6ppm was achieved, while Delaria et al. 2021 only reported: "a temperature-dependence correction, and a resulting network instrument error of 1.6 ppm CO2 or less".

Accuracy seems less relevant than the network error, but if accuracy is reported, please clarify if further accuracy testing has occurred and if this was done against the latest WMO CO2 X2019 scale or an equivalent scale established by a National Metrological Institute.

L119: Although non-highway sources are reported to be a minor contribution on average (ca. 12%) this is not sufficient information as it could maybe contribute a lot more during certain hours and a lot less during others. Please consider adding a diel cycle of the non-highway CO2 component to the main paper or report a range here, instead of the average of 12%.

L133: Has this interpolation method been validated? It would be crucial to show that this linear interpolation works well or how much additional uncertainty it introduces. A quick test would be to choose a period with complete coverage, randomly remove 50% of data and see how we you can reproduce the true time series.

L148 – equation 1.: This is unclear, shouldn't er_i be a speed dependant variable here? Or vehicle classes indeed vehicle-speed classes?

L164: How well does the PeMS data reflect actual vehicle speeds on the highway? Is there a significant amount of uncertainty added here?

L167: See comment at L90

L173: Please define congestion here. Is anything below free-flow considered congestion? For example, if the average speed on a segment is 60mph instead of the posted 65mph would that count as congestion?

L194 – Equation 4: suggestion, do not CO2 as variable to signify CO2 emissions, as you already used it to signify CO2 mixing rations (see Figure 1, right top). Maybe use E(CO2)/vkm =

L197: Please elaborating the 5% assumption. 'Because eight of the nine points corresponding to emission rate bins fall within 5% of the fit, we estimate that the BEACO2N system would be able to detect a change in emissions rates of the order of 5%'

Is there a statistical theorem that shows that this follows?

L203: please add 'g' to CO2/vkm

L219: Air quality is not at all discussed in the results section of the manuscript and it is not included in the emission modelling or inversion results, so any discussion of it seems speculative – maybe better put in a 'outlook' section than a discussion. See general comment

L225-229: Why are AQ proxies discussed here, although no data or modelling of AQ proxies is included in the study?

L 243: see general comment on AQ

L 247: see general comment on AQ

L 267: change ‘avail-able’ to ‘available’

L278/L285/L288/L325 please add required information for reference. E.g. DOI, website accessed, etc.

L353 – Figure 1: As the manuscript uses SI and SI-derived units I would assume that the label ‘tons’ in Fig. 1 right-bottom refers to 1000kg. If not please highlight the use of the common US short-ton.

L360 – Figure 2: textbox in left figure nearly unreadable if printed on letter-size paper.

L368 – Figure 8: figure right shows only 8 points, while L 197 referred to 9 points. Why was one point omitted here?