

## ***Interactive comment on “A mobile sensor network to map carbon dioxide emissions in urban environments” by Joseph K. Lee et al.***

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Received and published: 11 July 2016

Lee et al. propose a measuring system based on a mobile network of sensors to validate estimations of carbon dioxide (CO<sub>2</sub>) emissions at fine spatial resolution (i.e. grid cells of 100 m<sup>2</sup>) in urban areas. They built and tested an initial network of five sensors as a proof-of-concept. The sensors are basically formed by a commercial CO<sub>2</sub> monitor and a Global Positioning System (GPS) connected to a low-cost controlling board and placed in a special box for being carried on mobile platforms such as cars and bicycles.

The CO<sub>2</sub> concentration data collected by the sensors along roads, streets and paths of the city are used to estimate emissions applying an aerodynamic resistance approach and sensible heat flux data obtained from an eddy covariance flux tower located within

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a sector of the city monitored. As a proxy of the aerodynamic resistance of CO<sub>2</sub>, they used the aerodynamic resistance of sensible heat under the strong assumption of equivalence between both.

The testing results showed the capability of the mobile network to complement eddy covariance flux measurements and validate emission estimates based on activity data and emission factors. The proposed monitoring system represents a new tool to solve the puzzle of the greenhouse gas emissions at city scale. As any other approach, it has advantages and limitations. Both are discussed in the manuscript.

The description, discussion and validation of the proposed approach fit well within the scope of Atmos. Meas. Tech. This work represents, in general, a valuable contribution to the ongoing efforts to quantify urban emission in a way to support policies for climate change mitigation.

The technical issues to be addressed are minor. However, this reviewer cannot recommend the immediate publication of the manuscript because of severe problems in the writing. The structure of the manuscript is appropriate, but the writing is not good enough for a scientific paper. A number of sentences are repetitive and others confusing. The manuscript needs a comprehensive editorial revision to be considered for publication.

After the technical comments, a number of editorial suggestions are listed for the first ten pages of the manuscript. This reviewer expects they can provide some insight on how to fix the writing in general.

Technical comments (Page/Line)

Since the mobile CO<sub>2</sub> measurements were conducted along roads and streets, the approach is biased to traffic emissions. How this issue could be addressed, in particular for other trace gases, such as methane, whose origin relies in source emissions other than traffic? Please emphasise this issue even more.

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Data-driven models in combination with databases of urban parameters, such as land-use, building characteristics, population density, vehicular traffic, etc. at fine spatial scale may help to identify grid cells of similar characteristics and better estimate their emission. They could be used to extrapolate emissions for those cells not included in the sampling transects, as well as to determine the ideal number of sampling points per cell. If those databases are available, the approach proposed here may improve significantly its performance. See Moosavi et al., Atmos. Meas. Tech. 8, 3563-3575, 2015.

10/21-24 Was the stationarity criteria for the eddy covariance flux data used to remove suspicious periods during the mobile measurements? I mean, if a flux measurement period did not meet the stationarity criteria, were the mobile data collected during the same period also discarded?

Table 2 & 3. Are statistically different ( $p \leq 0.05$ ) the concentrations/emissions recorded/estimated between the grid cells of each neighborhood and between neighborhoods?

21/4-6 How do you explain that the measured emissions were in average higher in summer than in winter, contrary to the estimated emissions by bottom-up approaches?

21/23 Indeed, the approach lead to realistic and consistent results in average when evaluated at neighbourhood scale, but not at fine scale (i.e. grid cells).

22/10-14 The comparison should be restricted to the same periods of the day on weekdays and same climatological seasons.

Editorial suggestions (Page/Line)

1/11 Why the use of quotation marks?

1/17 Eighty seven percent (summer) and 94% . . .

2/3 Define directly and indirectly emissions. Not all readers might be familiar with these

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terms.

2/10 It depends on the latitude (e.g., Velasco et al., Landsc. Urban Plan. 148, 99-107, 2016).

2/15 Avoid acronyms to start a sentence.

2/16 Does it sound better quick or fast instead of agile?

2/24 The research goal of this study/work is to develop . . .

2/25-27 Rewrite. For example: Data from a network of mobile sensors and an eddy covariance flux tower combined with an aerodynamic approach are used to calculate and map . . .

2/28 Mobile measurements have been used . . .

2/30 mobile monitoring methods rely on a . . .

2/31 – 3/2 These two sentences are repetitive, merge them with the previous one.

3/3 I would say interest instead of success.

3/4 Top-down data mining?

3/8 Not all readers might be familiar with “bottom-up approaches”.

3/16 “Autonomous flying vehicles” sounds like science fiction.

3/3 – 3/17. The whole paragraph needs to be rewritten. This reviewer does not consider necessary the discussion on the use of open-source microcontrollers in combination with cell-phones as a proxy to map environmental parameters. This work proposes the use of instrumentation specifically designed for measuring CO<sub>2</sub>.

3/20 This study investigates the feasibility for mapping greenhouse gas emissions, specifically CO<sub>2</sub> . . .

3/22 Replace “car sharing platforms . . . or random vehicles” by “mobile platforms”.

3/24-28 These four bullets sound more like the manuscript's structure rather than the objectives. Rewrite them in one paragraph.

4/1-2 Never leave titles/subtitles without text. Don't use uncommon acronyms for a title. All acronyms need to be previously defined in the text.

4/4 This sentence is repetitive.

4/5 What about "passenger" instead of "various"?

4/7 Define limited time-scale and fine resolution. One, two five hours? Grid cells of 50, 100, 500 m<sup>2</sup>?

4/9-10 ... have been stationary or mounted in specialized vehicles ...

4/13-16. Rewrite the whole paragraph. For example: Carbon dioxide analysers based on infrared detection (Licor ...) were coupled with microcontrollers (Arduiono ...), etc.

4/14  $12.23 \times 15.25 \times 7.62$  cm

4/16 No need "... monitoring applications including agriculture."

4/19 Define GPS.

4/27 Material of the tube?

5/Panel b. Which is the height of the sampling line over the vehicle's roof?

5/Figure 1 legend. It is clear that both panels show photos of the CO<sub>2</sub> system. No need of indicating that during operation the system is enclosed in the case neither that the used vehicle was a car-shared one.

6/10 Indicate that in Canada, the driver position is at the left side.

6/19-26 Rewrite the whole paragraph.

6/20 Provide locations using latitude and longitude in degrees.

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6/27 Flux tower measurements.

6/28 Eddy covariance flux tower ...

6/28 No need to include the Fluxnet ID of the flux tower. The manuscript never makes reference to Fluxnet.

6/28 – 8/9 This paragraph needs to be rewritten. Indicate since then the flux tower has been working. Provide a reference to a comprehensive description of the tower.

7/Figure 2 legend. Avoid repeating information already given in the text (e.g.,  $12.7 \times 1$  km). Try to use active sentences as much as possible (e.g., The location of the flux tower is marked by ... instead of Shown are also ...).

7/Figure 2 legend. Crawford and Christen, 2014 is a very good paper, but I do not consider necessary to include it here.

8/11-15 Rewrite the whole paragraph. For example: Two fields campaigns took place, the first on ... during the summer and when trees leaves are in full, while the second on ..., covering the heating season. Sampling was conducted from 10:00 – 13:30 h, when vehicular traffic and meteorological conditions are relatively constant.

8/16. Remove this sentence.

8/17 Replace predefined by designed.

8/16-19 Rewrite these two sentences.

8/23 Should be bicycle instead of bike?

9/3 Describe briefly such filtering methods.

9/20 Data from the eddy covariance tower are ...

10/Eq. 3 So many conversion factors at the beginning of the equation are confusing. Merge them in only one factor and explain its meaning in the text.

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10/15 Remove “in the two measurement campaigns”. It is obvious.

10/26-30. Make shorter this sentence. For example: This assumption is supported by a previous study in which no storage flux was observed during daytime for this particular site (Crawford and Christen, 2014).

11/1-3 Any reference on the Reynolds analogy?

11/11 Better indicate the percent of excluded or included readings.

14/Table 2. Indicate which those climate zones are.

23/17 ... between 9:00 and 19:00 h ... This might be true for office buildings, but not for residential buildings. 23/30 ... the traffic count data do not indicate ...

24/7-9 Do not list what others have made (you did it already in the introduction), better say that this study was the first in combining ... to evaluate CO<sub>2</sub> emissions at fine scale.

25/19 Replace six tanks by six standard gases

27/12 ... to the Open Street Map (OSM) ...

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-200, 2016.

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