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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Atmospheric inversion for cost effective quantification of city CO_2 emissions" *by* L. Wu et al.

L. Wu et al.

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Anonymous Referee #4

COMMENT:

The paper by Wu et al., entitled "Atmospheric inversion for most effective quantification of city CO2 emissions" seeks to answer the question: how much uncertainty reduction in carbon emissions from cities can urban networks observing atmospheric CO2 yield? This is a very timely topic, as the COP21 meeting is underway in Paris as I write this review. The paper is written well, and the inversion methodology is sound. However, I have one major concern regarding the assumptions underlying cheaper sensors that may render results from the "cheap" network overly optimistic. I would like the authors to address this concern before the paper is published in its final form.

RESPONSE:

We thank the reviewer for this positive general comment on the paper, and for having helped the paper better focusing on its strongest material and better discussing the assumptions on the low cost sensors.

COMMENT:

MAJOR COMMENT:

The authors appear to be making a lot of assumptions regarding “cheap sensors” that are not substantiated by evidence. In short, I am not aware of cheap sensors that can perform as well as the authors assumed. Can the authors cite specific peer-reviewed references that illustrate the ability for these sensors to perform as well as assumed?

RESPONSE:

This study analyzes the potential for future dense networks. The discussion section raises the need for low-cost medium precision (LCMP) sensor instead of state of the art high-precision instruments if willing to deploy such dense networks. Our assumption that LCMP sensors could be available for atmospheric inversion in the near term is fueled by initial laboratory testing of LCMP sensors at LSCE (figure attached to this response). This and previous work have been funded by the climate KIC innovation projects, such as MIRIADE and SMEVOUCHER (http://www.climate-kic.org/projects/miriade/). Unfortunately, these studies have not been published yet due to non-disclosure agreements, but publications are planned for 2016. Even though these sensors and their calibration strategy do not fulfill all conditions for a wide deployment in an urban network with the assessed precision, these results are encouraging and manufacturers are interested to continue their development towards LCMP sensors in the future.

The paper will better focus on the OSSEs. Accordingly the title will be changed to

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"What would dense atmospheric observation networks bring to atmospheric inversion for the quantification of city CO2 emissions?"

We will mention, in the discussion section, LCMP sensors to justify why the use of 30 to 70 site networks could be realistic in the future. The accuracy and cost of the sensors and network infrastructure will be discussed in terms of requirements in appendix, and briefly in the discussion section. This discussion section will state that present test of LCMP sensors are promising regarding the expectation that such sensors with the required precision could be available for atmospheric inversion in the near term.

COMMENT:

If there are systematic errors in the cheap sensors there could very well be erroneous emissions that would be solved for by the inversion system. For instance, if the cheap sensors measure systematically higher CO2 mixing ratios over several hours, the inversion would retrieve higher emissions, naturally. This could require such sensors to be calibrated at significantly higher frequency (e.g., hourly), rather than the multi-day frequency assumed by the authors. Would this be feasible?

RESPONSE:

When analyzing the fluxes at the monthly scale, it is critical to know what is the resulting observation error for data averaged at the weekly to daily scale. Whether a given uncertainty on these averages arises from a high standard deviation (STD) of the observation error at the hourly scale but low temporal correlations or a lower STD but significant temporal correlations would not play a critical role for monthly mean results.

A consideration has led inverse modelers to compensate (assuming it would raise exactly the same results over monthly to seasonal scales) 1-hour to several day temporal autocorrelations of the measurement errors that they could not explicitly set up in their systems by increasing the STD of the measurement errors at the hourly scale (Chevallier, 2007). With that in mind, we consider that our tests of sensitivity to the observation

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errors, increasing the STD of the hourly scale errors, which are now described in the main text, address the potential impact of systematic errors on 1-month mean results. In these tests, we implicitly require calibrations to prevent systematic errors with temporal autocorrelation of more than a few days/week. Therefore, we now use these sensitivity tests to raise requirements on the accuracy and frequency of the calibration for the sensors rather than derive a fixed measurement errors based on assumption for such an accuracy for a given calibration strategy. We remark that, actually, our preliminary calibration results with LCMP sensors favor achieving such requirement.

COMMENT:

Note that the comment about "systematic errors should not have long autocorrelation timescales" on Page. 30706 Lines 9_10 is erroneous. By definition, systematic errors have a non-negligible autocorrelation timescale!

RESPONSE:

Calibrations prevent systematic errors from having long autocorrelation timescales. There is no strict definition of systematic errors. But for such sensors, they characterize the instrument drifts and biases that can be corrected for through regularly applied calibrations, with a residual error that haves some temporal autocorrelations whose timescales should not exceed the calibration periods.

COMMENT:

A type of measurement network that the authors have yet to explore is the combination of deploying both high-precision and cheap sensors in the field, which may be a likely way forward in the near-term, while the cheaper sensors are still undergoing improvement. The high precision sensor(s) would help detect gross errors in the cheap sensors, helping to prevent systematic errors in the retrieved fluxes, as mentioned in the aforementioned scenario.

RESPONSE:

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This is a very nice suggestion. We can see that potential of using travelling high-precision instruments (Hammer et al. 2013, http://www.atmos-meas-tech.net/6/1201/2013/amt-6-1201-2013.pdf) within the network to verify the LCMP performance. This would be consistent with what has been done for the atmospheric CO2 European network. This will be mentioned in the updated discussion on the potential for having 30 to 70 site networks in the near term, even though this does not impact the core part of the new version of the paper now focusing on the OSSEs.

COMMENT:

MINOR COMMENTS:

1) Page 30696, Line 12: The "Glaeser and Kahn 2010" reference appears to be missing

RESPONSE:

Thank you for pointing out this. We will add this reference.

COMMENT:

2) Page 30701, first paragraph: I found this paragraph difficult to follow, and it took several readings for me to rasp the main ideas. Reword?

RESPONSE:

We will clarify this paragraph.

COMMENT:

3) Sect. 3.4.3 H3: It would help the reader to explain here the scientific reason for why the CO2 gradients are considered. I realize that the reason can be found in the Breon et al. (2015) paper, but it helps the reader with a sentence like what is mentioned later: "": : :large spatial coherence of the errors from the model boundary conditions and from the estimate of the fluxes outside the IDF area, whose cancelling is the main aim of the gradient computation." I suggest this point to be mentioned earlier, in Sect. 3.4.3

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RESPONSE:

Thank you for your suggestion. We follow it. More generally, we will improve the general presentation of the method.

COMMENT:

5) Page 30718, Line 21: “not correlated in time neither in space” => “not correlated in time or in space”

RESPONSE:

Thank you for your correction. We will follow it.

COMMENT:

6) Page 20725, Line 20: a missing key reference on the use of stable carbon isotope measurements to partition anthropogenic vs biogenic sources is Pataki et al. [2003]: Pataki, D. E., D. R. Bowling, and J. R. Ehleringer (2003), Seasonal cycle of carbon dioxide and its isotopic composition in an urban atmosphere: Anthropogenic and biogenic effects, Journal of Geophysical Research, 108(D23), 4735, doi:4710.1029/2003JD003865-004735, doi:003810.001029/002003JD003865.

RESPONSE:

Thank you for your suggestion. We will add this reference.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 30693, 2015.