Atmos. Meas. Tech. Discuss., 4, C1983–C1986, 2011
www.atmos-meas-tech-discuss.net/4/C1983/2011/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Towards space based verification of CO_2 emissions from strong localized sources: fossil fuel power plant emissions as seen by a CarbonSat constellation" *by* V. A. Velazco et al.

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Received and published: 5 November 2011

First of all, we thank the two anonymous referees for their comments, suggestions and ideas that serve to improve this manuscript. Advances in science depend not only in researchers but also on their peers willing to spend precious time in contributing to the review process. We have addressed all the referee's comments and outlined them below.

1. Comments from anonymous referee #1 regarding the lack of proper analysis of the current uncertainties of power plant emissions and CarbonSat's comparison with CEMS' maximum uncertainty.

Author Comment: We agree that there is a lack of proper analysis of uncertainties in power plant emissions. This is because in general, there are also very few published scientific works addressing the topic. We now clarified in the manuscript that the +/- 14% value presented by Peischl et al, 2010 is a maximum allowable difference of values obtained by CEMS compared to individual tests, and not error bars or standard deviations. Furthermore, we mentioned that the "uncertainty" of the CEMS are reported to be <1% for CO2 concentration and <5% for flow rate, as mentioned in Evans et al., (2009). Therefore, the total uncertainty of CEMS CO2 is about < 5.1%.

Under Results and Discussions, we further add:

"By contrast, hourly mass emission rates reported by Electric Generation Utility (EGU) power plants in the U.S. equipped with CEMS are reported to only require an accuracy of 14% or better (Peischl et al., 2010), despite the fact that the CO2 flux estimates from CEMS can have an uncertainty of <5.1% (Evans et al., 2009). CEMS can also be used in the EU-ETS as long as the comparison with calculated data shows equal or less uncertainty. As however pointed out by Evans et al., 2009, "uncertainty as it is used here has nothing to do with accuracy (i.e., closeness to "truth" or lack of bias) ... only with the precision or repeatability of the data." Moreover, the CO2 calculation approach used in the European Trading Scheme may have a bias of up to 20% in annual CO2 emissions compared to direct measurement according to Evans et al. (2009). This was based on a study that was done on power plants with capacities of $\sim$500 MW (i.e., power plants emitting approximately 5 MtCO2/year)." In another study, Ackerman and Sundquist (2008) investigated annual CO2 emissions from 828 coal-fired power plants. They compared two databases - the EPA eGRID database containing directly measured CO2 and the Department of Energy's Energy Information Administration (DOE/EIA) database of fuel data from individual power plants. Ackerman and

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Sundquist (2008) found that the average absolute difference between calculated and (within stack) measured annual CO2 emissions was 17.1% (Table 1 of Ackerman and Sundquist, 2008). Based on their analysis, Ackerman and Sundquist, 2008, concluded that “it is important to recognize that the ongoing quantification of accuracy and uncertainties will always require the application of multiple estimation procedures.”

Note that we do not claim in our manuscript that CarbonSat or a CarbonSat constellation will be able to outperform the accuracy or precision of the CEMS-based monitoring systems. We cite the corresponding references only to indicate what the current state of the art monitoring in terms of achieved accuracy and precision is. In fact in most countries the reported annual emissions are not based on CEMS or equivalent systems but on calculated values. In this context a relevant publication is Evans et al. (2009) and their finding that large differences exist between calculated and measured emissions (they typically found differences of 0.5-1 MtCO2/year for 500 MW power plants emitting approximately 5 MtCO2/year, i.e., biases of 10-20% for annual CO2 emissions.

2. Referee comment regarding unaccessible presentation of Evans et al., (2009)

Author Comment: Sorry for this inconvenience, the paper, which is a conference paper, can be accessed via <http://www.theclimateregistry.org> through the link: <http://www.theclimateregistry.org/downloads/2009/05/Clean_Air_Engineering_-_How_Reliable_are_GHG_Combustion_Emission_Factors.pdf>
A complete version can be directly downloaded from: <http://renovaqualidadedoar.com.br/site/file/1_4%20How%20Reliable%20are%20GHG%20Combustion%20Emission%20 (please copy and paste the whole link onto the browser if automatic redirect does not work). The URL where the paper can be downloaded is now written in the references.

3. Referee comment regarding equation 3, 4 and 5 (classical matrix approach) being unnecessarily complicated and that the equation could just be written as VAR(E) = SUM(VAR(Ei))/nËĘ2,

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Author comment: Thank you for this comment, we have written this formula in the end.

4. Referee comment regarding Figure 2 not showing the expected weekly cycle, with emissions on Saturdays seeming to be larger than on Mondays.

Author Comment: True. The same weekly cycle has been observed by Petron et al., (2008) (Fig. 4). In that study, they showed the average weekly cycle of CAMD CO2 emissions calculated for each month (January to December) using data from 1998 to 2006. Interestingly, the emissions are generally higher in the middle of the working week. Also, Monday emissions can be lower than emissions on Saturdays for some months. We have included this observation in the revised manuscript but cannot provide a conclusive explanation to this at the moment. Petron et al., (2008) also did not provide a conclusive explanation to the weekly cycle, apart from citing holidays that are celebrated on fixed days of the week (e.g. Thanksgiving on the last Thursday of Nov.).

5. Referee Comment regarding random errors in the abstract.

Author Comment: The random errors are now mentioned in the revised version of the abstract, thank you.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 5147, 2011.