Atmos. Meas. Tech. Discuss., 8, C488–C497, 2015
www.atmos-meas-tech-discuss.net/8/C488/2015/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Design and application of a mobile ground-based observatory for continuous measurements of atmospheric trace-gas and criteria pollutant species" *by* S. E. Bush et al.

S. E. Bush et al.

susanelainebush@gmail.com

Received and published: 2 April 2015

Referee comments are preceded with "RC" in the following text. Author response to referee comments are preceded with "AC" in the following text.

RC: General comments:

RC: Specific questions regarding quality assurance: 1) Was the platform tested for self-contamination from the vehicles own exhaust? 2) How well do the individual in-

struments perform under mobile measurement conditions? 3) Have there been any experiments in order to assess how representative the measurements with this setup and at these sampling heights are?

AC: The location and placement of the sampling mast with mounted atmospheric inlet plumbing was such that measurements were taken from near the front of the vehicle (opposite the exhaust location) and 3 m above the road surface. This, along with forward motion of the vehicle would not allow for contamination associated with the vehicle exhaust system unless the tail wind speed exceeded vehicle speed, which is not possible under operating conditions. In actuality, we didn't see evidence for self-contamination from the vehicle itself even when stationary.

RC: "The application section is rather poor. . ." "Showing a little bit less examples and going a little bit more into details would be desirable."

AC: Showing fewer examples and more detail is one approach for highlighting the utility of this mobile platform. We chose to utilize a different approach with the goal of showing more examples at the cost of less detail.

RC: The conclusions section should include a discussion about limitations of the setup.

AC: Incorporating discussion of the following limitations of the setup in the conclusions (specifically paragraph starting P47L25) would not be unreasonable: 1) We don't have any way at the moment to assess distance to vehicle in front of the lab on the road. 2) Even with wind data, if there are multiple sources of impact in any given direction, it is not possible to link the data collected to the point emissions source unless it can be linked because of its association with a specific atmospheric constituent – methane for example is linked to certain processes and not others. 3) As with many types of atmospheric measurements, a big challenge is to relate measured atmospheric concentrations to land surface fluxes. However, at least in mobile mode, this platform was not designed to measure fluxes, but rather to provide spatial information on greenhouse gas concentration fields. 4) The main limitation of on-road measurements, from

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this mobile platform and others, is that observations are necessarily limited to the road network. Hence, distance to different emissions sources (and thus signal strength for mobile observations) is determined by an external, confounding factor.

RC: Detailed Comments:

RC: General: In some sections the term “mobile observatory” in others “mobile laboratory” is used preferentially. Are these terms used as synonyms?

AC: Standard definitions of observatory and laboratory refer to a place equipped for observation of natural phenomena and may also include opportunity for experimentation. We do not think the choice of words was in error or inappropriate.

RC: P34L9-10: Here you claim to perform “high-precision” measurements. In the manuscript you do not provide any information on the precision of the measurements.

AC: Additional information regarding instrument precision was provided in references and/or direct links to additional instrument manufacturer resources.

RC: P35L19-21: Do you have references to support these statements?

AC: Yes. L19-21 is the topic sentence for the paragraph and each of those statements is addressed in the order presented in the topic sentence following in the body of the paragraph with references cited.

RC: P35L19-P36L8: In addition to these examples of stationary measurements there are also many measurements of pollutants and pollutant distributions in urban environments performed with mobile laboratories. Examples are Herndon et al., Faraday Discussions 2005 (Mexico City, Boston), Thornhill et al., ACP 2008 (Mexico City), Wang et al., ACP 2009 (Beijing), Elanskii et al., Dokl. Earth. Sci. 2010 (Moscow), von der Weiden-Reinmüller et al. AMT 2014/ACP2014 (Paris).

AC: The focus of this paragraph was greenhouse gas emissions and the references cited were consistent with the content of the paragraph.

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RC: P37L14-17: Even though most mobile laboratories are only designed for either mobile or stationary measurements, this is not true for all platforms. For example, the mobile laboratory described in Drewnick et al., AMT 2012 is designed for both, mobile and stationary measurements.

AC: The statement in the text: "In cases where the capacity for the measurement of multiple variables exists, the facilities are typically large, oversized vans or recreational vehicle platforms, designed to provide stationary (tower based) or mobile functionality, but not both" is worded to indicate that one or more of these is generally the case. The Drewnick et al platform does have the capacity for the measurement of multiple variables and represents an example of having both stationary and mobile measurement capacity. However, it was constructed using a larger oversized van platform relative to the compact transit connect described here. "(but see Drewnick et al)" can be added following the text.

RC: P37L22ff: Is there an extra AC unit installed in the vehicle or is it cooled with the regular unit of the vehicle? In order to improve the logical flow I suggest re-ordering the sub-sections of section 2: After the general part (now between 2 and 2.1) first 2.2, then 2.1, then 2.4 and finally 2.3.

AC: No, there is not an extra AC unit installed in the vehicle. It is cooled with the vehicle AC unit. We think the order of the sections in 2 are fine as they are.

RC: P37L26-27: For me it is not clear why just this vehicle was selected for public outreach goals.

AC: It was selected for its small, compact size and fuel efficiency characteristics. The size and door locations of this vehicle make it easy to show instrumentation to the public without having them enter the vehicle.

RC: P38L7-8: Is the mast custom-built?

AC: Yes, the mast was custom built.

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RC: P39L19: Why are there independent inlet lines for the different gas phase instruments? What is the material of the second inlet line?

AC: Not all instruments were incorporated at the same time. As instruments were added, so were additional plumbing lines, as space on the mast was not a limiting factor. The material for the second inlet line was PTFE tubing, consistent with instrument manufacturer recommendations.

RC: P40L2-5: The flexible tubing is probably not aligned perfectly vertically down into the instrument. Do you have any ideas on losses in this inlet line? The isokinetic sampling probe mentioned here is equipped with several nozzles which are optimized for different relative velocities between the probe and ambient air. Do you switch between nozzles depending on vehicle speed and wind speed or do you choose one as best compromise?

AC: Although the lab is equipped with an isokinetic sampling probe for mobile aerosol measurement capability, it is not currently mounted and we only ever used that sensor while stationary. We are willing to modify the text accordingly.

RC: P40L14: How does the met station provide “true wind speed “ and direction?

AC: The instrument combines a spatial and wind speed measurement. A GPS is used to obtain the speed and course of the vehicle over the ground, which is then combined with apparent wind speed and direction measured (the combined measure of atmospheric conditions and vehicle motion) in order to calculate true wind speed and direction.

RC: P40L23-24: From the point of view of the vehicle these are only two different electrical sources: external power (from generator or from the grid) and vehicle alternator.

AC: The statement was written from the point of view of the user, in which case there are three: grid, generator, or vehicle alternator. However, we agree to modify the sentence to read from the point of view of the vehicle if necessary.

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RC: P41L18: What is the power of the alternator?

AC: Stock alternator that came with the vehicle: 150 A

RC: P41L24: Instead of “160 min reserve capacity at 25 A” why don’t you just provide the energy of the battery (66 Ah)?

AC: The text can be modified according to suggestion.

RC: P42L27: During the measurements “adjacent” to the fire line: how distant was the fire line?

AC: We did not have exact distance measurements to the fire line during sampling. However, the active fire line had descended to near the valley floor where the road was located, and the valley width was approximately 1 km wide at its widest locations.

RC: P43L4: Are you sure the area is 87 945 km2 and not 87 944.8 km2?

AC: Rounding up 2/10ths of a km2 for the Greater Los Angeles metropolitan area is not unreasonable, particularly given that metropolitan boundaries are not necessarily clearly defined with that level of precision anyway.

RC: P43L24-25: This definition of “background” level does not account for regular diurnal variations. They would appear as “excess” pollutant concentration in the data. How do you deal with this?

AC: The monthly mean mole fractions are compiled from flask data, for which the time stamps indicate collection times that span different time periods of the day, rather than a mean that is representative of daily minimums or maximums. But regardless, the diurnal variation at the Wendover site is so small relative to 1) the generally elevated minimum in urban environments (most of the applicable data) and 2) the magnitude of variation observed within the urban environment and at Trinity Ridge, that this is not an issue.

RC: P44L11-25: How do you distinguish between elevated pollutant levels at the traffic

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lights due to elevated ambient levels in this area and due to sampling very close to the tailpipe of the vehicle in front of your mobile observatory? Sampling on roads always has the disadvantage that the measured levels are strongly dependent on the distance to the vehicles in front of the mobile observatory. At traffic lights this distance is very low. This problem results likely in an overestimation of pollutant levels in areas where the distance between cars is small (e.g. at traffic lights). According to Figure 4 the CO levels partially exceed the 8-hour level but not the 1-hour level. So generally since the levels are only exceeded for short times this should not be the problem. It is hard to believe that it is a problem for people working or living close to such an intersection: These people do not live or work ON the intersection but dozens of meters away from it. Here the fact that such a measurement on the road overestimates the local pollutant levels (e.g. several meters or tens of meters away from the road) becomes quite important. Therefore I strongly suggest that such effects of positive biases by emissions from local sources (e.g. the vehicle in front of the mobile observatory) are discussed.

AC: It was not possible to distinguish between elevated ambient levels and sampling very close to the tailpipe of a vehicle in front of the mobile observatory. However, we note the symmetrical nature of increased trace-gas levels, which would not be expected when sampling very close to the tailpipe of a vehicle in front of the mobile observatory.

RC: P45L4-5: From Figure 5 I cannot see this interaction with boundary layer growth and decay. The maximum values are largest during the morning measurement, much lower during the afternoon measurement and slightly larger again during the nighttime mea- surement. However, during the morning measurement large concentrations are limited to a small fraction of the trip while during the other two measurements the concentra- tions are more evenly distributed. Therefore the average concentrations show a very different temporal behavior compared to the maxima. From this it is hard to extract any information on boundary layer height influence.

AC: We are willing to remove “and interacted with boundary layer growth and decay” from this sentence.

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RC: P45L19-P46L2: It is unclear to me what the information of this example is.

AC: The mobile observatory is a useful tool for examining trace-gas emissions dynamics at regional spatial scales.

RC: P46L3-22: This example seems to be almost free from local contamination (e.g. ve- hicles around the mobile observatory) and consequently provides robust information on the distribution of potential sources. It would be interesting if the hot spots of el- evated methane concentrations observed in this measurement would be associated with potential sources and the impact of such sources onto the environment would be discussed.

AC: We agree that a detailed analysis of methane hotspots, potential sources, and impacts on the environment would be useful. However, that was not the focus of this particular manuscript and we have addressed that in detail in another manuscript – see Hopkins et al in review

RC: P46L23-P47L8: The information of the measurements presented in Figure 10 would be much more informative for the reader if for the different km ranges it would be indicated what was measured at these location (i.e. wildfire at certain distance, urban air, :::).

AC: The nearest urban center (aside from small communities in the area that had been evacuated) was Mountain Home, Idaho, approximately 100 km distant, and would not have had an impact on measured values. We did not have access to exact distance to the active fire line data during this time. See previous comments addressing this above.

RC: P47L10f: You state that you have presented examples that highlight the utility of the mobile platform for addressing carbon cycle and public health related questions. It would be interesting to learn in this section how such data could be used and what kind of information could be extracted from them to address such questions. Furthermore,

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it would be adequate to discuss not only potential but also limitations (and how to deal with them, e.g. with contamination by other vehicles, wind direction dependences, limited coverage of the area) of the mobile observatory in this section.

AC: Regarding the first part, although we do not provide an exhaustive list for what and how such data could be used, we do address this: “In particular, this observatory is well suited for providing high spatial and temporal resolution measurements to link with current emissions model products (e.g., Hestia)(Gurney et al., 2012)”. Regarding the second part, as indicated previously above, adding text to address limitations in the second paragraph of the conclusion section 4 does not seem unreasonable.

RC: Figure 1: Can you add the isokinetic aerosol inlet to this schematic?

AC: The isokinetic aerosol attachment is not currently mounted on the vehicle – see previous comment.

RC: Figure 3: This Figure would better fit into the sections on the vehicle setup. The quantum cascade laser instrument which is in the middle of the instrument tower was not described in the text. Either adapt the text to this photo or use a photo that is in agree- ment with the text.

AC: It was mentioned in the text (P47L27), but not described in detail. We don’t see any issue with this image. In fact it highlights the versatility of the mobile platform given that the instrument was easily incorporated for the duration of an intensive measurement campaign.

RC: Figure 4-7 and 8: What does the length of the bars indicate? Also pollutant mole fraction as the color?

AC: The length of the bars and associated color both illustrate differences in mole fraction – where for length of bars, longest length=highest concentration.

RC: Figure 5: According to the text each trip took about 3 hours. Can you indicate which part of the morning trip (Fig. 5a) was during the rush hour and which part was

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after it? One has to be aware that each of the figures is not a snapshot but was measured over such a long time interval that during this time changes in emissions could have occurred.

AC: Doesn't the fact that we mention the approximate time frame required to complete this transect make the reader aware that each of the figures is not a single moment snapshot in time, but was measured over a longer time interval?

RC: Figure 8 and 9: It would be interesting to have information on the location of potential sources that cause the various peaks in CH4 mole fraction. How do these peaks depend on wind direction?

AC: As was mentioned previously, we agree that a detailed analysis of methane hotspots, potential sources, and impacts on the environment would be useful. However, that was not the focus of this particular manuscript and we have chosen to address this subsequently in independent manuscripts.

RC: Figure 10: What do the maxima in CO, CO2 and CH4 excess mean, what do the maxima in the ratios mean? What is from fire, what from other sources?

AC: Given the description of the atmospheric conditions at the time of sampling provided in the text, these data are dominated by a fire emissions source and that maxima clearly show concentrations highly elevated above background in this area during this time.

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