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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.

Anonymous Referee #1

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In their manuscript "Design and application of a mobile ground-based observatory for continuous measurements of atmospheric trace-gas and criteria pollutant species" S.E. Bush and coworkers present their mobile observatory and its setup together with several examples for applications of this platform. The manuscript consists of three main parts. In an extensive introduction the authors provide an overview of measurements in the target fields of their mobile observatory and a short overview of existing mobile laboratories. In the platform design section the authors describe their mobile observatory in detail, including the general setup of the vehicle, the instruments, the power supply

system, data acquisition and analysis and the measurement locations. Finally, in the application section the authors present a number of examples of measurements with the mobile observatory were spatial distributions of various pollutants were determined along the driving route.

Generally, the manuscript is compact and well written in a clear and easy-to-understand language and with a clear structure. The literature is reasonably well covered, taking into account that the introduction covers several different areas of research. For some of the statements additional references (see comments below) would be desirable.

The introduction is rather a motivation than an introduction to the "design" of a mobile observatory. The vast majority of the introduction covers the different types of potential applications for the mobile observatory and provides motivation for mobile measurements in these fields of research. As a consequence the overview over existing approaches how to design a mobile laboratory is rather short (see comments below).

The mobile observatory design section is very informative and detailed. Almost all relevant information is provided to understand the setup of the platform. Besides minor issues, the major lack of this section is the complete absence of any quality assurance work. The setup is described here, however nothing is provided about validation work performed for the new platform. Was the platform tested for self-contamination from the own exhaust? How well do the individual instruments perform under mobile measurement conditions? Have there been any experiments in order to assess how representative the measurements with this setup and at these sampling heights are? These are three out of many potential questions one could investigate with such a new setup in order to obtain field data of high and known quality.

The application section is rather poor. Examples for potential applications are shown. This makes sense in such a paper. However, showing a little bit less examples and going a little bit more into details would be desirable. In several of these examples I wonder whether the conclusions are really valid (or what the conclusions actually are),

taking into account that possible artefacts might dominate the results in some places. In all examples the authors fail to critically assess the quality of the data and the discussion of the potential information of the data – beyond the pure presentation of pollutant distribution along the measurement track – is also rather short. This section would probably gain significantly if fewer examples would be presented and for these examples a critical assessment of the data would be performed and potential information that could be drawn from these measurements would be discussed. This would much better show the actual potential and limitations of the new setup.

Finally, in the concluding section not only the potential applications but also the limitations of the setup and potential solutions to overcome these limitations (e.g. additional instruments, certain ways of performing the measurements or of analyzing the data) should be discussed.

Generally, I think, this manuscript is well suited for Atmospheric Measurement Techniques. However, it could be significantly improved by a more self-critical assessment of the own work – both, in terms of platform development and of its application. After including these rather minor revisions and dealing with the detailed comments below I suggest publication in AMT.

Detailed Comments:

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

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.

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

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 Dis-

cussions 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).

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

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 subsections 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.

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

P38L7-8: Is the mast custom-built?

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

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?

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

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.

P41L18: What is the power of the alternator?

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

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

P43L4: Are you sure the area is 87 945 km^2 and not 87 944.8 km^2?

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?

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

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 measurement. However, during the morning measurement large concentrations are limited to a small fraction of the trip while during the other two measurements the concentrations 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.

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

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

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, ...).

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, 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.

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

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 agreement with the text.

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

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 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.

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?

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?

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