Atmos. Meas. Tech. Discuss., 5, C942–C949, 2012
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Atmospheric Measurement Techniques Discussions

Interactive comment on "Design of a mobile aerosol research laboratory and data processing tools for effective stationary and mobile field measurements" *by* F. Drewnick et al.

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Received and published: 15 May 2012

Anonymous Referee #1

Referee #1: This paper presents a mobile laboratory built for air quality monitoring of gas and particle pollutants. Overall this is a very useful "tool" containing a large suite of instruments useful for studying local and regional air quality issues. Clearly a lot of effort went into the design. There are several comments listed below that should be addressed.

Referee #1: The MOLA is presented as having the capability of making measurement while mobile and Figure 9 shows some high time resolution CO2 data for mobile (and

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stationary) periods. However, it is difficult to view the highly time resolved measurements shown here (and in Figure 7). The authors should present some results of other measured species (beyond CO2) demonstrating the capabilities of fast time resolved measurement for gas and particles. A figure (or two) showing correlations, perhaps with CO2 or CO, would be supportive. Something that shows the near 1 Hz measurements would really help illustrate the capability and utility of this system. Such a correlation would also address the discussion presented in section 6.3 "Local Contamination Effects and Filtering Methods". Would not a scatter plot of a gas or particle pollutant versus CO2 be a means to separate the local perturbations from background levels?

Author reply: As suggested by the reviewer we extended Figure 9 by adding high-time resolution particle data (particle number concentrations) and by showing the high time resolution for a cutout of the data. In addition we show a scatter plot of CO2 and particle number concentration data. Both, the cutout as well as the scatter plot show that some of the local contamination events are mainly found in the CO2 data while others are primarily observed in the particle data. Therefore such a scatter plot is not very helpful in reliably identifying local contamination events. This is now also discussed in the section that deals with algorithms to identify local contamination (section 6.3).

Referee #1: The second sentence in the abstract states "Major efforts were made to design an aerosol inlet system which is optimized and characterized for both, stationary and mobile measurements". I guess what the authors mean by "characterized" is by modeling only. Were any measurements performed to support these calculations? If not this should be clearly stated.

Author reply: The reviewer is correct: the inlet system was mainly designed and characterized using a modeling approach. To state this clearly in the abstract we changed the sentence to: "Major efforts were made to design an aerosol inlet system which is optimized and characterized for both, stationary and mobile measurements using a particle loss modeling approach." Measurements of particle transport losses in tubes

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with simple geometries were performed to validate the Particle Loss Calculator calculations. We added a statement in section 2.2 where the development of the inlet system is described in detail: “The first step was the development of a software tool to calculate sampling and transport efficiencies through user-defined tube systems on the basis of parameterizations from the existing literature and validated with measurements for simple tube geometries.” In addition, the residence times of particles in the inlet system for the various instruments were both calculated as well as measured.

Referee #1: pg. 2276 line 20 references other mobile lab measurements of megacitites. Please add the following references:

S. C . Herndon , J. H . Shorter, M. S. Zahniser, J.Wormhoudt, D. D. N., K. L. Demerjian, C. E. Kolb Environ. Sci. Technol. 2005, 39, 7984-7990

S. C. Herndon, J. T. Jayne, M. S. Zahniser, D. R. Worsnop, B. Knighton, E. Alwine, B. K. Lamb, M. Zavala, D. D. Nelson, J. B. McManus, J. H. Shorter, M. R. Canagaratna, T. B. Onasch, C. E. Kolb, Faraday Discuss., 2005, 130, 327–339.

Author reply: The first of these two references deals with measurements of bus emissions using chasing experiments with a mobile laboratory. It would be an appropriate citation for “vehicle chasing” experiments mentioned a few lines above. However another paper dealing with the same experiment (Canagaratna et al., 2004) was already cited there. Therefore, and since we only present a selection of citations here, we do not cite this paper as well. The second one of these references deals with the general possibility to measure pollutant distribution within a megacity (Mexico City) and within Boston. It is another good example for what we present here in our manuscript. We therefore added this reference as suggested by the reviewer.

Referee #1: Figure 5 is mostly illegible as presented; maybe consider omitting this figure or presenting it schematically.

Author reply: Figure 5 is actually intended to provide a schematic overview only over

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both the design and the content of the on-line data acquisition using the live data display tool. It is not intended to provide detailed information on the individual axis labels. To make this clearer we pixelized all axis labels and small illegible text and re-sharpened the larger text in a revised version of this figure.

Anonymous Referee #2

Referee #2: The paper describes the design and operation of the MoLa laboratory for stationary and mobile measurements. The development of this facility is of interest for the scientific community and it should be published. No revision are requested at this stage, except in the abstract where authors should add the geographical location of the MPIC.

Author reply: The geographical location of the MPIC was added in the abstract.

Referee #2: The authors mention the fact that laboratory space is available for instrumentation brought by other laboratories during common filed campaigns, they also should discuss whether they foreseen to make the whole facility available to other laboratories in the framework of collaborative projects.

Author reply: Due to the complexity of the whole facility, including the instrumentation and data acquisition/processing the mobile laboratory will not be made available to external users for autonomous measurements. However, in the framework of collaborative projects in which we are actively involved we already have and also will in the future host “guest instruments“ from partners to measure together with our instruments. In order to make this clearer we changed the related sentence to: “Extra space and sampling ports at the main inlet line are available to accommodate additional “guest” instruments from partners for specialized measurements during common individual projects”.

Anonymous Referee #3

Referee #3: This paper describes the design of a mobile air pollution laboratory. Such

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mobile labs already exist but it is still worth to publish the concept of this new mobile laboratory which can serve as a reference for the work at Mainz but also guidance for other groups building such a lab.

Referee #3: I recommend publication after minor revisions:

Referee #3: - There is little information given on the reasons for the choice of the individual instruments. For some parameters, especially trace gases, instruments with better precision and time resolution exist that were probably not chosen because of money constraints or maybe others like power, etc.

Author reply: As stated in the first sentence in section 3.1 the major focus of the mobile laboratory is on the analysis of aerosol parameters. We added information on the most important criteria for the selection of the instruments: "The related instruments were chosen to provide a combination of in-depth aerosol information with time resolution in the lower second range as far as possible." As already mentioned, trace gas information is not a major focus of the mobile laboratory and therefore only "monitoring grade" instruments providing "basic information" on trace gas levels have been installed. This was already clearly stated in the first sentence of section 3.2.

Referee #3: - page 2285 : brand of webcam?

Author reply: The brand and model number of the webcam is already provided in footnote 16 to table 2 where all non-aerosol instruments are listed.

Referee #3: - The Grimm EDM 180 does not really particulate mass but light scattering. It might be regarded as an approximation of the mass. How does the sum of the measured composition compare to the mass derived from the Grimm?

Author reply: This is correct. We added this information in Table 1 together with the size range used for the mass concentration approximation. The EDM180 is certified for official monitoring applications within the EU and the US. As other monitoring instruments (e.g. beta gauge) it measures PM indirectly using certain assumptions. In

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this case the most critical assumption is a 'typical' particle size distribution in the lower nanometer size range. The mass concentration from this particle size range is calculated from the size distribution measured above 250 nm using such assumptions. As long as no extremely and unusually large mass concentrations in this size range exist in the atmosphere the estimated mass concentration can be assumed to be a good approximation. Our comparisons of ambient background concentrations measured with AMS and MAAP compared to EDM180 PM1 concentrations show good agreement. However, as mentioned above, this can break down if extreme concentrations of very small particles (like undiluted fresh diesel exhaust) are measured.

Referee #3: - page 2290/Figure 7: How do the authors explain the high particle number levels upwind of the city? How well do in general the CPC and FMPS data compare?

Author reply: Figure 7 is just an example for a stationary measurement application without going too much into the details of the data analysis. It is intended to show the general characteristics of the two measurements. The similar average particle number concentrations within and upwind of the city are caused by a larger "baseline" concentration during the "background" measurement, which is balanced by the short and intense peaks in the city. The reason for the larger background concentration is likely the fact that during this measurement an additional source was probed, which was sufficiently upwind of the measurement site to generate well-mixed constant concentrations. To describe this further we added the following explanation to the text: "Average particle number concentration levels are similar for both measurement locations. The lower "baseline" level in the city compared to the "background" measurement (apparently affected by additional sources further upwind) is balanced by multiple short and intense peaks." Generally CPC and FMPS data compare very well. For a recent field campaign of 4 weeks length CPC total particle number concentrations were compared to the total number concentrations calculated from FMPS data. Both number concentration data sets correlate well with an R2 of 0.85. In this comparison the CPC measured 9% larger number concentrations on average what is in agreement with the

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fact that the lower particle cut-off of the CPC is at 2.5 nm while the FMPS measures particles above 5.6 nm diameter only.

Referee #3: - page 2291: reformulate: the sulfate distributions reflect the air mass origin: “Sulfate reflect the sulfur emissions where the air mass originates from” .. or similar)

Author reply: As requested the sentence was reformulated: “However, no such dependence on population density can be observed in the sulfate distributions which reflect rather the sulfur emissions far upwind of the sampling locations than local source densities.”

Referee #3: - page 2294, line 4: The best suited instruments/parameters for this purpose depend strongly on the brand and type of instrument. The suitability of other parameters than particle number and carbon dioxide are possible when using other instruments.

Author reply: We did not want to give a general statement of which type of parameter is best suited for identification of pollution events. We wanted to state which parameters in our measurements are best suited for this purpose. We therefore added the word “our” to the sentence to make this clear: “Our CPC particle number concentration measurements and CO2 measurements, both having a time resolution of one second, proved to be best suited for this analysis, with the particle number concentrations being advantageous over the CO2 concentrations due to their typically lower noise level.”

Referee #3: - page 2294, line 20: Can this procedure be described a bit more mathematically?

Author reply: As requested by the reviewer we added a brief mathematical description to the sentence: “The increase in the threshold is determined using a random walk method (threshold = 3âĂćsigmab + sqrt(n)âĂćsigmab, with n number of data points since last uncontaminated point) and accounts for the normal temporal development of

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the background levels."

Referee #3: - page 2295: The authors should also compare to the method proposed by Bukowiecki et al. (2002) and that was also used in Bukowiecki et al. (2003). They describe the use of a low percentile in a moving window which should be discussed here as well.

Bukowiecki et al. (2002) A mobile pollutant laboratory - measuring gas phase and aerosol ambient concentrations with high spatial and temporal resolution, Atmos. Environ., 36, 5569-5579.

Bukowiecki et al. (2003) Fine and ultrafine particles in the Zürich (Switzerland) area measured with a mobile laboratory. An assessment of the seasonal and regional variation throughout a year, Atmos. Chem. Phys., 3, 1477-1494.

Author reply: A brief discussion of the method described by Bukowiecki et al. (2002) and why we did not use this method to separate background and contamination in our data was added to the text as requested by the reviewer: "Also Bukowiecki et al. (2002) presented a method to automatically separate the background from peak concentrations, based on a percentile method. In that method the 5% percentile within each minute was chosen to reflect the uncontaminated background concentrations. The drawback of this method is that for minutes without contamination the resulting background concentrations will be biased low while for highly contaminated data (>95% of all data points contaminated, e.g. in heavy traffic) contamination will be regarded as background. In addition, this method provides a characteristic value for each one-minute interval but does not identify contaminated time periods and thus cannot be used to correct for contamination in lower time-resolved data. Therefore we did not further use this approach for our data."

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 2273, 2012.