Atmos. Chem. Phys. Discuss., 9, C4989–C4996, 2009
www.atmos-chem-phys-discuss.net/9/C4989/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Use of a mobile laboratory to evaluate changes in on-road air pollutants during the Beijing 2008 Summer Olympics" *by* M. Wang et al.

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Received and published: 20 September 2009

We would like to thank the referee#1 for the comments and suggestions, which contribute to improve the quality of our paper. We have implemented all the comments and suggestions in the revised manuscript. Below please find a detailed point-by-point response to each comment.

Comment 1: The present manuscript contains a number of referencing errors. Because these occurred on the first two pages there may be more, as I am not familiar with all the references cited. The Rogers et al. 2006 reference on line 14 page 12859 describes the use of a PTR-MS for on-road characterization of VOC emissions from in-

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use vehicles and has nothing to do with fine PM. The mobile lab studies described in Jiang et al. 2005, Rogers et al. 2006 and Zavala et al. 2006 all describe measurements made in Mexico City.

Response: Accepted. We have corrected the reference errors, please see page 3, line 11. It is true that all of the references written by Jiang et al. 2005, Rogers et al. 2006 and Zavala et al. 2006 describe measurements conducted in Mexico City. The purpose we cited these references is to address the current developments of mobile laboratory researches in different countries and these papers showed good examples in Mexico City.

Comment 2: The authors need to more clearly describe the temporal nature of their measurements so that readers that not knowledgeable with on-road measurements can understand and critically evaluate the results. Statements such as that made on lines 28 and 29 on page 12860 “The temporal and spatial distributions of air pollutants within and around the city were characterized...” need to be justified. Measurements made on-road reflect the interception and detection of individual vehicle exhaust plumes superimposed onto the local ambient background. Vehicle density and velocity in conjunction with local wind direction dictate the frequency, magnitude and duration of the vehicle exhaust plume encounters. Measurements were conducted on what appears to be a heavy traveled roadway – several thousands of vehicles per hour. Given this sampling environment it seems certain that the measurements were dominated almost exclusively by emissions from nearby vehicles, potentially obscuring any information concerning the local, much less the regional, background. Some method of distinguishing between these direct exhaust measurements and those representing the ambient background must be made before the authors can substantiate their claim of characterizing the air pollution “surrounding and within the city”. The technique of using simple averages certainly does not adequately address this task.

Response: (1)We added more detail descriptions and revised sentences, figures and tables about the temporal nature of our measurements.

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On page 10, line 5 to 14, we stated “Generally, these measures were classified into before (before 19 Jul 2008), during (20 Jul 2008-19 Sep 2008) and post (after 20 Sep 2008) full-scale control periods, based on the magnitudes and scales of control measures. The full-scale control period included comprehensive control for industrial and construction activities, traffic emission as well as gas evaporation. To better clarify the effectiveness of different control measures especially during the Olympics and Paralympics, we further divided the full-scale control period into four stages: before Olympics(20 Jul 2008-7 Aug 2008), during Olympics(8-23 Aug 2008), between Olympics and Paralympics(24 Aug 2008-6 Sep 2008), and during Paralympics (7-19 Sep 2008).”

To further highlight the temporal variation of level of on-road air pollutans, we revised table 2 by merging table 2 and table A1, adding two columns showing corresponding periods of different control measures based on the statements above.

(2) Accepted. On page 4, line 24, we deleted the sentences “The temporal and spatial distributions of air pollutants within and around the city were characterized...”

(3) It is true that the concentrations of on-road air pollutants are determined by various sources. As Jiang et al.(2005) stated “The continuous measurements of pollutant concentrations represent three categories: 1) fresh tailpipe exhaust, 2) on-road background, and 3) exhaust contaminated by emissions from the mobile lab’s engine and generator”. Several methods were used to distinguish the direct vehicle exhaust plume and ambient background. Bukowiecki et al. (2002) regarded 5% percentile values of each 1 minute time windows as background. Jiang et al.(2005) measured the “baseline” by parking their mobile lab away from traffic and regarded it as background. However, our study focuses on the effectiveness of various control measures, especially the traffic control; we did not discard peak values caused by exhaust of passing vehicles, because the level and the frequency of these peaks are determined by the traffic control measure. On the other hand, we agree with the referee’s suggestion that individual vehicle exhaust with long duration and local wind direction may influence the

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accuracy of our measurement data, and we did take measures to avoid this. On page 11, line 1-7, we add more description about our method: “Given to the interferences of the immediate emission exhausts in front of the mobile lab with long duration, several methods are used to identify and exclude these emission plumes. These include (1) driving the mobile lab at a constant speed of 60 km/h on the road with 80 km/h speed limit, and carefully keeping more than 30 meters distance from the vehicles in front. (2) checking the wind direction of the incoming wind by meteorological sensor on top of the mobile lab near the sampling inlets. (3) using video camera to check when extremely high peak concentrations appear.”

The traffic flow of the Fourth Ring Road seems heavy, but it is a four-lane road at each direction, and the two directions are separated by a well-isolated belt where the influence by vehicle exhaust plume encounters may be minor.

Comment 3: The description of the sample inlet system is insufficient to demonstrate how it works. The gas phase inlet, as described, appears to be an open tube that relies on the forward motion of the vehicle to push the sample gas through. Given the critical impact that sampling methodology has on the validity of any measurement, a more complete and thorough description of the inlet and its testing must be included. For instance, from what is described it is not obvious why the gas phase instrument don’t simply pull sample through both ends of the tube. Given the apparent rudimentary nature of the sampling system, experimental characterization of its efficacy should be presented. A thorough description of how this inlet was modified when the mobile laboratory was parked for the inter-comparison study is also required. Self-sampling is a critical issue and is not eliminated simply by vehicle motion, tail winds and convection currents created by rapidly passing vehicles can also produce self-sampling. These concerns should not be simply dismissed, a well designed mobile laboratory experiment will have specific methods to recognize when its own vehicle exhaust and/or generator emissions are contaminating its sampling system and proven protocols for recognizing and either rejecting or correcting self-emission affected data. There cer-

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tainly must have been times when the mobile laboratory was not operated at the stated 60 km/hr.

Response:(1)We add a new section 2.2 about inlet system and rewritten the description following the referee's suggestion. More details on the constructions of each inlet, like the way they work and their efficiency tests were carefully described. Please find page 5, line 17 to page 7, line 2: "As shown in Fig. 1, four individual sampling inlet systems were constructed to minimize pollutant loss during the sampling and to enhance the ..." Meanwhile, we also made changes to figure 1 by enlarging inlet images to make its construction more clear.

(2)To describe the intercomparison more clearly, we added the following sentence on page 9, line 18 to 23: "The instruments on PKU monitoring station for intercomparison such as NOx, CO, SO2 and BC were the same as those in the mobile lab, and a standard PTR-MS (Ionicon) was used on PKU monitoring station. Calibrations for each of the instruments were conducted everyday with similar method as the instruments on the mobile lab. Calculated loss effiencies for gas-phases and BC while stopping for intercomparison were less than 1%(Hinds, 1999)."

(3)We agree that self-sampling is an important factor influencing the accuracy of measurement data, and have taken measures to test and to avoid it. Details on these methods have been described on page 11, line 8 to line 18: "Self-contamination by exhaust from the engine and generator of mobile laboratory is also a critical factor that should be tested and eliminated before the measurements. In addition to minimize the influence by previous statements methods that using UPS batteries as power supply as well as installing sampling inlet forward, the mobile lab was maintained at a speed of 60 km/h, or 17 m/s, which is much higher than the normal wind speed in Beijing. So during the measurement trip, the exhaust of the vehicle from the backside of the vehicle could not reach the front by wind. To exam the level of self-contamination, the mobile lab was driven at 60 km/h on a new highway between Beijing and Tianjin, where only a few vehicles were on the road. The concentrations of air pollutants measured at

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this road were close to the background level, e.g. the NO concentration was observed less than 3ppb, this confirmed that self-contamination of the platform is negligible in our study."

Comment 4: The virtue of making high time response measurements is in the ability to distinguish the proximity of the emission source. Any direct sampling of vehicle emissions will certainly lead to obvious correlations between compounds that known to be present in the exhaust. Conversely the lack of temporal correlations with combustion tracer species can be used to confirm the presence of solvent emissions. Daily averages might capture these events, but time series plots in conjunction with correlation scatter plots should be used to help validate or corroborate such an assertion. Vehicle exhaust plumes from passing traffic generally only last several seconds while the duration of solvent plume intercepts of the larger more dispersed solvent plumes should last sufficiently long for the temporal variability in the benzene and toluene responses to provide a clear distinction between vehicle exhaust and solvent emissions.

Response: Accepted. Following the referee's suggestion, we selected toluene as painting solvent indicator and NOx as traffic emission indicator and calculated their correlations every day. The figure 8 was changed by adding correlation coefficients(r). Meanwhile, we added sentences to make the results more conclusive, please see page 19, line 12 to 18: "To further demonstrate this suppose, a daily correlation between Toluene (solvent indicator) and NOx (traffic emission indicator) has been calculated (SPSS 15.0) and shown in Fig. 8. Apparently, correlations(r) from 19 July to 4 August were low($r<0.22$), while after August 4, the correlations jumped to higher than 4 most of time. This significant difference was tested by two-tailed t-test(SPSS 15.0), showing $p<0.01$. This provides evidence that contribution from painting was reduced after August 5."

Minor comment 1: The designation of LDV, MDV and HDV should only be used if the size of the vehicle reflects the type of engine.

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Response: Accepted. A sentence was added LDVs and MDVs, (mainly using gasoline engines) , and HDVs (mainly using diesel engines), please see page 11, line 22-23.

Minor comment 2: The authors have contradictory statements: On line 21 page 12870, the benzene and toluene concentrations reported before July 20 indicate a B/T of 0.46. On line 22 page 12872 it states that prior to August 4th that B/T were lower with an average value of 0.26.

Response: Accepted. The B/T of 0.46 before July 20 on line 22 page 12872 was calculated by the average value of benzene to toluene from July 18 to 19. However, as shown in Fig. 8, B/T ratio started to drop below 0.22 from July 19 and the absolute high benzene and toluene concentrations in July 18 with respect to July 19 may lead the average B/T ratio from July 18 to 19 to be more close to the B/T ratio on July 18. To aviod the misunderstanding of the dates, we changed the dates “before 4 Aug” into “from July 19 to Aug 3”.

Minor comment 3: Section 3.6 This is the best section in the manuscript. It shows real data and describes how the temporal variability in the data was used to discriminate different emission sources.

Response: Thanks for the comment.

Reference:

Bukowiecki, N., Dommen, J., Prevot, A. S. H., Richter, R., Weingartner, E., and Baltensperger, U. : A mobile pollutant measurement laboratoryâĂŤmeasuring gas phase andaerosol ambient concentrations with high spatial and temporal resolution, Atmos. Environ., 36, 5569–5579, 2002

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Interactive comment on Atmos. Chem. Phys. Discuss., 9, 12857, 2009.