Atmos. Chem. Phys. Discuss., 8, S7774–S7781, 2008
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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Traffic restrictions in Beijing during the Sino-African Summit 2006: aerosol size distribution and visibility compared to long-term in situ observations" *by* Y. F. Cheng et al.

Y. F. Cheng et al.

Received and published: 1 October 2008

We would like to thank Referee #2 for the careful reading of the manuscript and for the thoughtful comments. We have addressed the comments below; reviewer's comments are in italics with our responses following.

1. *In Section 3, the paper presents different impacts of traffic restrictions on the number concentrations of particles at different modes, but the explanation for this is far from convincing or coherent throughout the paper. For example, on page 12976, line 18-21, the authors state that the increases in the number concen-*

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trations of nucleation model particles during the Summit is due to an increase in new particle formation. In the abstract (line 10-12), the authors state that the secondary particle formation actually decreases during the traffic restriction. They are contradictory statements, unless there have been differences in the formation rate of new particles and secondary particles. However, the authors do not differentiate the two types of particle formations in the paper.

Reply: Yes, the descriptions in Section 3 and the abstract are misleading.

As we indicated in the introduction of the manuscript, traffic emissions are considered to be one of the most important sources of sub-micrometer particles in the urban area of Beijing (Zhang and Shao, 1997;He et al., 2001;Zheng et al., 2005;Song et al., 2006 etc.). Zheng et al. (2005) and Song et al. (2006) indicated that, as a primary source, traffic emissions in Beijing contribute 6-7% to particulate mass concentrations below 2.5 μm (PM2.5). However, gaseous pollutants are also emitted by vehicular sources, such as NOx and organic compounds, which are essential for the atmospheric photochemical processes and subsequent gas-to-particle conversion. The latter are closely related to the formation of secondary particulate matter. In total, secondary ammonium, sulfate and nitrate contribute over 35% of PM2.5 in Beijing (Zheng et al., 2005;Song et al., 2006). However, this percentage does not include the contribution of secondary organic particles. Zheng et al. (2005) reported that particulate organic matter accounted for over 50% of PM2.5 in the urban area of Beijing during winter time, of which less than 30% might be explained by biomass burning (Duan et al., 2004).

Therefore, any traffic restriction in Beijing would reduce not only the primary particle emissions from vehicles, but also the secondary particle sources since the precursors of secondary particles were reduced, too. However, when the concentrations of Aitken and accumulation mode particles decreased, the condensational sink of particles also decreased. This would favor the new particle for-

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mation (Wu et al., 2007). But at the same time, condensation and heterogeneous reactions on existing particle were reduced. So, as on average, the secondary particle contributions to the sub-micrometer would be also reduced due to the traffic restriction during the Summit 2006 in Beijing.

The corresponding descriptions in the manuscript have been clarified.

2. *In Figure 1: the time series do not contain enough days before or after the Summit: only four days before and one day after. To make a convincing statement about the impact of traffic restrictions, longer period is desired.*

   Reply: As requested also by reviewer #1, we have enlarged the time scale of Figure 1 from 31 October to 13 November 2006 (see Fig. 1 in this response, as well as the updated Figure 1 in the manuscript), including additional weekend days 11-12 November (Sat-Mon). No obvious "weekend effect" was found after the inclusion, as we already mentioned in the manuscript that long-term statistical analysis do not support any "weekend effect" on particle number size distributions in Beijing (Wu et al., 2008). Previous studies (e.g., Xia et al. (2008)) did not either find clear weekly cycles of aerosol optical depth over Eastern China.

3. *Section 5, page 12981, line 14-17: the paper states that the differences in particle number concentrations between the Summit and non-Summit period are not significant when the wind speed was larger than 6 m/s. However, Figure 2a indicates that these higher wind speeds ($>$ 6 m s^{-1}) tend to occur more often in the daytime during the Summit when the impact of traffic restrictions is expected to be the greatest. Indeed, Table 2 shows that the data points during the Summit with wind $>$ 6 m s^{-1} represent more than 1/3 of all the data. Thus the paper’s conclusion about the impact of traffic restrictions on particle concentrations is biased toward low wind speed conditions which occur more often at night during the Summit and when the traffic restrictions have minimal impact on emissions. The authors need to investigate the biases. I suggest the authors restrict their*

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comparison for the daytime hours (both Summit and non-Summit period) and re-evaluate their selection criteria for the non-Summit period to include more high wind speed data (i.e., $>$ 6 m s^{-1}).

Reply: This is a good point. According to the suggestions by both reviewers, we tried the following steps to estimate the possible bias.

First, we inspected the complete data sets from November 2004, 2005 and 2006. Except for the Summit period, we could not find much many strong wind data with wind speeds higher than 6 m s^{-1}. So, we cannot adjust the data selection criteria to include more strong wind data points as suggested.

Second, statistically, there is no problem with our data selections. However, we also realized that there could be the situation that the program just selected continuously low winds into the wind speed class 0-3 m s^{-1}, while during the Summit, the slow winds followed the strong winds or were in between. And it is reasonable that the PM data may be different between the continuously stagnant weather conditions and the low wind conditions after pollutant removal processing with strong wind, even though they are both within the same low wind class (e.g., 0-3 m s^{-1}). But as we discussed before, there were not enough data within the wind speed class $>$ 6 m s^{-1} in the November 2004, 2005 and 2006. So it is not possible for us to estimate the influence of the strong wind ($>$ 6 m s^{-1}). However, based on the 2-year statistical analyses, Wu et al. (2008) found that the particle volume concentration, especially the accumulation mode particles, was strongly dependent on the wind speed and direction. As shown in Figure 8 of the paper by Wu et al. (2008), the removal efficiency of fine particles kept nearly steady when the wind speed was higher than $\sim$ 4 m s^{-1}. So, we did an additional filtering on the selected non-Summit data set. The low wind speed data point (e.g., 0-3 m s^{-1}) would only be kept if within 24 hours there was a strong-wind period (greater than 4 m s^{-1}, and also satisfied other non-Summit criteria as before). This means that the low wind speed data points and strong wind speed ones during the non-

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Summit periods were also connected. The number of data points within the wind speed class of 0-3 m s^{-1} decreased from 540 to 253, and no change to other wind classes.

The comparison of the average particle number size distribution in the wind speed class 0-3 m s^{-1} before and after the re-filtering is presented in Fig. 2 in this response. After re-filtering, the number concentration in the nucleation mode increased whereas the number concentration of the Aitken mode and accumulation mode decreased. Also the peak of the particle size distribution shifted to a smaller diameter ($\sim$ 70 nm) from 100 nm.

The additional filtering processing has been added into the manuscript in Section 4. The results and discussion of wind speed class 0-3 m s^{-1} have been modified in Section 5 and Figure 3 in the manuscript. Also condensational sink and visibility were re-calculated and modified in Section 6.

After the non-Summit data re-filtering discussed above, we tried to separate the data sets into daytime (7:00 to 19:00) and nighttime (19:00 to 7:00 of the following day) for wind classes of 0-3 m s^{-1} and 3-6 m s^{-1}. There were not enough data in wind class $>$ 6 m s^{-1} to do the same analysis.

The daytime and nighttime comparisons between the Summit and non-Summit periods are presented in Fig. 3 and Fig. 4 in this response. In each wind speed class, the shapes of fine particle number concentrations are similar during daytime and nighttime, whereas the fractions of coarse mode particle in the total particle volume concentrations are higher during nighttime, especially in wind class 3-6 m s^{-1} during Summit period. An interesting finding is that during both Summit and non-Summit period the fine particle concentrations are similarly lower during night time than those during daytime, which is opposite to the general understanding of the diurnal variation of PM which usually accumulates during nighttime due to the lower boundary layer and reduced vertical mixing in the night.

Concerning the control effect of the traffic measures during Summit, we also calculated the ratio of particle number concentration at each diameter between Summit and non-Summit for daytime and nighttime for each wind classes. The results are shown in Fig. 5 in this response. As expected by the reviewers, we do see a relatively stronger reduction effect in the Aitken and accumulation modes during daytime than that in the nighttime.

The discussions regarding to the difference of reduction effects between the daytime and nighttime have been added to the manuscript.

4. *Page 12983, line 22-24: the paper states that “the number concentrations of particles” in the Aitken and accumulation modes was reduced by 40-60% during the Summit period. But in the abstract (page 12972, line 10-12), the text states “the source strength” of these particles was reduced by that much. It’s important to understand the difference between sources and concentrations – they are not equivalent measures. A 40% reduction in sources normally does not result in a 40% reduction in concentrations and vice versa. The statement in the abstract about the ‘source strength’ has no support evidence in the text and thus is not correct.*

   Reply: Yes, you are correct. The relation between the source and concentration of atmospheric particulate matter is very complicated. And they are not equivalent measures. We have corrected this statement in the abstract as "... under comparable weather conditions, the number concentrations of the particles in Aitken and accumulation modes ...".

5. *Related to the above comment, the paper focuses on direct comparison of particle number concentrations, but is lack of discussion on the traffic restrictions on emissions. As indicated in the introduction of the paper, the news states 30% of vehicles were taken off the road during the Summit. Does the authors’ analysis agree with the 30% reduction on vehicle fleet reported by the news?*

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Reply: As the reviewer has already pointed out above, for atmospheric particulate matter, a certain percent reduction in sources normally does not result in the same percent reduction in concentrations and vice versa. And the relation between the source and concentration of atmospheric particulate matter is very complicated. However, we have only measured the ambient number concentrations of particles. And unfortunately, we do not have access to accurate estimate how much of flow of traffic and what types of vehicles were restricted during the Summit. Hence, we are not able to verify the present research results and further investigate the interaction between sources variation and the response changing of particle concentrations in Beijing.

6. *Page 12929, line 7: the back trajectory was run for 144 h or 6 days. Is there a particular reason to run such long-time back trajectories? What’s the typical lifetime of particles in the typical urban atmosphere in Beijing in Nov? The traffic restrictions were local actions and should not have big impact on surrounding environment. The 6-day back trajectory will over-emphasize the impact of regional influences and may lead to biases. I suggest the back trajectories shortened to match with the actual lifetime of particles in Beijing.*

   Reply: The lifetime of atmospheric aerosol particles is generally considered to be a few days to weeks (Seinfeld and Pandis, 1998). According to our knowledge, we can hardly estimate the lifetime of particles in Beijing. And the particle concentrations in Beijing are also influenced by the regional transport (Wehner et al., 2008). In the present study, using 144h ($\sim$ 1 week) back trajectories was aimed at characterizing regional weather conditions and air mass transport characteristics. It is important to notice that we have already applied linear decaying weighing factors u_j (see Equation 3 in the manuscript). This means that the nearest (regarding to the backward time) back trajectory point was the most important, whereas the further in backward time, the less the importance to the current concentration in Beijing was in our calculations.

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Figures

Please find Fig. 1. to Fig. 5. at

http://picasaweb.google.com/yafang.cheng/FiguresAcpd20080218_AC2?authkey=FtVXRIM0IRQ#.

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