Atmos. Chem. Phys. Discuss., 8, S7782–S7793, 2008
www.atmos-chem-phys-discuss.net/8/S7782/2008/

Atmospheric Chemistry and Physics Discussions

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 #1 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.

Reply to the Specific Comments:

1. *The authors alluded that the traffic restriction during the Summit served as a rehearsal for similar measure planned for the 2008 Olympics (pp 12974, 12982, 12984, 12987). However, it should be noted that the Olympics took place in*

August 2008, under very different meteorological conditions (winter vs. summer) and emissions sources (e.g., no heating).

Reply: Yes, we agree with the reviewer that the Beijing Olympics took place in August 2008, which was under very different meteorological conditions (winter vs. summer) and emissions sources (e.g., no heating during summer time). However, the statement that the traffic restriction during Sino-African Summit 2006 served as a rehearsal for the 2008 Olympic games stems from the news report of China Daily (2006). It has been also referred to as such by Wang et al. (2007) and Renfrow (2008).

In our opinion, to state this measure as a "rehearsal" was based on two points of view. First, it was a logistic rehearsal. During six days surrounding the summit (a smaller-scale gathering compared to Olympics), Chinese officials increased bus capacity, limited access to certain roads, and banned or restricted the use of government, commercial, and private vehicles (Beijing-Traffic-Management-Bureau, 2006). This made it easier for summit participants to get around Beijing, while also providing a logistical trial run that would benefit athletes and spectators in 2008. On the other hand, scientifically, we could take advantage of this natural experiment to improve our ability to detect pollution and see if the restrictions, which would have been also applied during the Olympics, had an impact on the air quality in Beijing.

- *a) It would be interesting to compare with the results of the traffic restriction demonstration conducted during August 2007.*

  Reply: Yes, indeed. It would be interesting to compare with the results of the traffic restriction demonstration conducted during August 2007. But unfortunately, our measurement project did not cover this time period.

- *b) The analysis was based on observations at one site (Peking University). How well does this site describe PM across Beijing?*

ACPD

8, S7782–S7793, 2008

Reply: Wehner et al. (2008) analyzed 2-year ambient particle number size distributions in Beijing between 2004 and 2006 as a function of regional meteorological transport. They indicated that an earlier examination of the spatial variability of PM2.5 mass and chemical composition in 1999-2002 showed only minor differences between the campus site (Peking University, PKU) and a downtown site. And consequently, they assumed that the PKU site were representative for the Beijing urban environment.

2. *The authors indicated that traffic emissions appear to be responsible for only a very small percentage (6-7%) of the fine PM in Beijing. On page 12973: 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 micrometer (PM2.5). However, according to the authors (page 12986): Based on statistical analysis of long-term observation, under certain weather conditions, the source strength of the particles in Aitken and accumulation modes was reduced by 40-60% during the period of 4 to 6 November 2006, when the traffic restrictions were in place. This may be mainly due to the reduction on the secondary particle source. Furthermore, on page 12987: If we assume that there were no traffic restrictions taking place and with normal level of the vehicle emissions during the Summit period, the visibilities during 4-6 November 2006 would have been lower by about 50%.*

   - *a) Were there other measures besides traffic restrictions during the Summit, e.g., biomass burning, industrial activities?*

     Reply: According to the government statement (Beijing-Traffic-Management-Bureau, 2006) and the news report (China-Daily, 2006), there were no other measures besides traffic restrictions during the Summit 2006.

   - *b) What types of vehicles were restricted? Gasoline? Diesel?*

ACPD

8, S7782–S7793, 2008

Reply: 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, even though this information would be interesting and very useful to verify the present research results and to further investigate the interaction between pollution sources and air quality in Beijing.

Statistical data showed that population of diesel vehicles only accounted for $\sim$ 5% of Beijing's total vehicle population in 2004 (Xie et al., 2008).

- *c) The 6-7% estimated contribution of fine PM from vehicles was based on 2000 data (see Zheng et.al., 2005; reference for Song et al. is not complete); however, on page 12987, the authors mentioned that: new car registrations in Beijing keep growing by about 15% annually. The vehicle fleet in Beijing was therefore much larger in 2006 compared to 2000. Are there more recent emissions inventory data?*

  Reply: According to Beijing transport annual report (Beijing-Transportation-Research-Center, 2006), the total vehicle in Beijing was about 1.51 million in 2000. During the Summit 2006, the number of vehicle in Beijing was about 2.82 million. Utile the end of March 2008, this number has increased to 3.25 million. So, since 2000, the annual increasing rate of total vehicle in Beijing was about 11-12%. These data have been updated in the manuscript.

  We tried to look for more recent emissions inventory data in Beijing. Regarding experiment-based source apportionment (e.g., positive matrix factorization), we only found that Xie et al. (2008) published the source apportionment for PM10 in Beijing based on the samples collected in 2004. They indicated that contribution from vehicle emission accounted 5.0% to PM10 and exhibited no significant seasonal variation. According to the Asia inventory dataset developed in support of NASA's INTEX-B mission (Streets, 2006), in the site located grid, the transport (traffic) contribute less than 5% to PM2.5 as a primary emission source in 2006.

ACPD

8, S7782–S7793, 2008

3. *In order to select meteorologically consistent days for comparison with the 2006 time period when the traffic was restricted, the authors use PM data from selected days with similar wind direction and magnitude in 2004, 2005 and 2006. However, as pointed out above (2 c), the vehicle registrations were growing at 15% per year and congestion is increasing.*

   - *a) How do these vehicle and traffic trends influence the PM data in 2004 and 2005, which were used to compare with the 2006 traffic reduction period?*

     Reply: We agree with the reviewer that the growth of 11-12% per year of the new vehicle registrations and the increasing traffic congestion may influence the PM. But this impact is very difficult to verify.

     First of all, we have to admit that the source profile of fine particles in Beijing is very sparse. The data we could get are limited. As we have discussed in the reply to 2c), according to the open literature and accessible database, differences of the fractional contribution of traffic emission to fine PM during 2004 to 2006 were not obvious or not significant due to data uncertainties and different estimation algorithms. Secondly, even though the number of vehicles increased 11-12% per year, the total surface of roads and streets in Beijing only increased by $\sim$ 2% from 2004 to 2005 (Beijing-Transportation-Research-Center, 2006). At last, if we look at the long-term daily averaged data as shown in the Figure 1 of the paper by Wehner et al. (2008), no pronounced trend in the total particle volume with diameter less than 800 nm can be found from 2004 to 2006. So, we think using the PM data in 2004, 2005 and 2006 to compare with the Summit period is statistically acceptable.

   - *b) As shown in Figure 2: during the Summit period the wind direction was constant with persistent strong winds; however, the selected Non-Summit period (Table 2) includes only a small fraction of data points with stronger winds relative to weaker winds compared to the Summit period. Could this bias the estimated effects of traffic restrictions during the Summit?*

ACPD

8, S7782–S7793, 2008

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 by reviewer #2.

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 simply just 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 observation, Wu et al. (2008) statistically analyzed the correlation between wind speed and the particle volume concentration. As shown in Figure 8 of the paper by Wu et al. (2008), the removal efficiency of fine particles, especially the accumulation mode particles, kept nearly constant 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 satisfied other non-Summit criteria as well). This means that the low wind speed data points and strong wind speed ones during the non-Summit periods were also connected. The number of data points within the wind speed class of 0-3 m s^{-1} decreased from

ACPD

8, S7782–S7793, 2008

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. 1 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.

- *c) If the large effects are due to reduction in the secondary particle formation, the effects should be more pronounced by time of the day. Could the authors discuss the diurnal variation?*

  Reply: This is a good suggestion. But due to the limited samples, we cannot discuss the diurnal variation. If we do so, the statistical significance would simply become very poor. However, after the non-Summit data re-filtering discussed above, we do try 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. 2 and Fig. 3 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 dur-

ACPD

8, S7782–S7793, 2008

ing 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 class. The results are shown in Fig. 4 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 in the wind speed class of 3-6 m s^{-1}. In the low wind speed class (0-3 m s^{-1}), stronger reduction effect can be found for particles with diameters larger than about 90 nm.

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

4. *On page 12980, the authors stated that: Long-term statistical analysis does not support any weekend effect on particle number size distributions in Beijing (Wu et al., 2008). It should be noted that the Summit period (November 4-6, 2006) occurred on a weekend (Sat-Mon); perhaps the authors could show longer periods before and after the summit in Figure 1, i.e., the reduction comparison should include other weekend days in that figure.*

   Reply: We have enlarged the time scale of Figure 1 from 31 October to 13 November 2006 (see Fig. 5 in this response and updated Figure 1 in the manuscript), including additional weekend days 11-12 November (Sat-Mon). As shown in Fig. 5 in this response, 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.

ACPD

8, S7782–S7793, 2008

5. *The authors stated (page 12986, line 20): our analysis suggests that traffic restrictions could be effective in improving the air quality and reversing the climate change in Beijing and its surrounding areas. Please clarify how merely reducing traffic by 30% in Beijing would reverse the climate change in the Beijing area.*

   Reply: Yes, you are right. It is difficult to state the climate effect by just the data what have got during the three days traffic restriction (30%). So we deleted this statement concerning the climate change from the manuscript.

6. *How does the result of this study compared to studies in other urban centers related to traffic restrictions? e.g., the authors mentioned the Heilbronn experiment in June 1994 (page 12973).*

   Reply: We cannot compare our results with the Heilbronn experiment in June 1994, because that experiment was focused exclusively on the ozone issue.

Reply to the Technical Comments:

1. *P 12972, L 24: atmospheric - should be atmosphere?*

   Reply: Yes, it has been modified.

2. *P 12973, L 1: in particular, at diameter - perhaps should be in particular, with diameter?*

   Reply: Yes, it has been modified.

3. *P 12975, L 14: have been checked manfully - should be have been checked manually?*

   Reply: Yes, it has been corrected.

4. *P12978, L14: Clarify domestic heating - is this residential? What about nonresidential?*

ACPD

8, S7782–S7793, 2008

Reply: Yes, it is residential. And it has been clarified.

5. *P 12982, L 27: were been found - should be have been found?*

   Reply: Yes, it has been corrected.

6. *P 12983, L 2: It was found out that - should be It was found that?*

   Reply: Yes, it has been modified.

7. *P 12983, L 5-8: Rephrase the sentence: Compared to most of the back trajectories during the Summit period, the back trajectories with higher particle concentrations in the coarse mode during the night when wind speed ran ing 3–6ms−1 were mostly originated from more northern direction and subsided from about 2000m since 40 h away from Beijing.*

   Reply: Yes, this sentence has been rephrased as “In the wind speed class of 3-6 m s^{-1} during the Summit period, the higher particle concentration in coarse mode mostly occurred during the night time. At this time, the air masses originated from more northern direction from Beijing and subsided from about 2000 m within 40 h, compared to most of the back trajectories during the Summit period.”.

8. *P 12983, L 9: and no - should be and non ?*

   Reply: Yes, it has been corrected.

9. *P 12987, L 14: were occurred - should be occurred?*

   Reply: Yes, it has been corrected.

10. *P 12980, Eq 2: Provide more description in the selection of the weighting factors w and wz.*

    Reply: The aim to use the weighing factor of w_ξ and w_z is to balance the factor differences between the values of orientation and height. The absolute weighing

ACPD

8, S7782–S7793, 2008

factors were obtained by trail cluster calculations to better distinguish the different particle number size distributions (Engler et al., 2007). This information of reference has been added into the manuscript.

11. *P 12988: References: Some references are not complete; e.g., Song et al., 2006 - which journal?*

    Reply: Yes, the journal is “Atmospheric Environment”. And it has been added.

12. *- Update the references/statements related to the Olympics games.*

    Reply: Yes, we have updated the information in the manuscript related to the 2008 Beijing Olympics.

References

- Beijing-Traffic-Management-Bureau, http://www.bjjtgl.gov.cn/Article_tg.asp?AE_ID=418, 2006. in Chinese.
- Beijing-Transportation-Research-Center, Beijing transport annual report, Beijing, 136, 2006.
- China-Daily, http://www.chinadaily.com.cn/2008/2006-11/07/content_726767.htm, 2006.
- Engler, C. et al., Atmos. Chem. Phys., 7, 5785-5802, 2007.
- Renfrow, S., The Earth Observer, 20, 1, 4-6, 2008.
- Streets, D., http://www.cgrer.uiowa.edu/EMISSION_DATA_new/index_16.html, 2006.
- Wang, Y. et al., Geophys. Res. Lett., 34, L08814, doi: 10.1029/2007GL029326, 2007.
- Wehner, B. et al., Atmos. Chem. Phys, 2008. Accepted.

ACPD

8, S7782–S7793, 2008

Interactive Comment

- Wu, Z. et al., Atmos. Environ., doi: 10.1016/j.atmosenv.2008.06.022, 2008.
- Xia, X. et al., J. Geophys. Res., 113, D14217, doi:10.1029/2007JD009604, 2008.
- Xie, S. D. et al., Atmos. Chem. Phys., 8, 2701-2716, 2008.

Figures

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

http://picasaweb.google.com/yafang.cheng/FiguresAcpd20080218_AC1?authkey=CJaKv5Rl_Xg#.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 12971, 2008.