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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Air quality during the 2008 Beijing Olympics: secondary pollutants and regional impact" *by* T. Wang et al.

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Reply to referee 1's comments

"(1) The evaluation was done based on measurements at three sites, due to the spstial variation of ground-level ozone, I suggest that the authors to mention explicitly in the abstract and conclusion section that all the remarks were from only the three sites, not for the whole city of Beijing."

Reply: We will note this in the abstract and conclusion. Specifically, "urban Beijing" (abstract line 18) will be replaced by "at an urban site" which will also be added in conclusion (line 8, after " . . .still occurred"). "(2) In section 3.1, the authors could compare the measurements of SO2, NO2 and PM10 at the three sites to the API of the whole

city, to illustrate somehow the representativeness of their sites."

Reply: We did not measure PM10 at any of the three sites, thus cannot compute the API based on the data from our sites. As showed in Figure 1, the temporal pattern of the sulfate concentrations at CRAES tracked very well the API at the nearby BJEPB station, indicating the similarity in the variation of particulate matter at the two sites, although the absolute concentrations may differ.

"(3) In line 5-25 on page 12441, the tracers for vehicular exhaust needs to be more specific, and in the discussion on the changes of sources, the gasoline evaporation source will need to be mentioned, the municipal government put great efforts addressing VOCs emissions from storage, transport and gasoline stations."

Reply: We meant NOx, ethene, ethyne, benzene, toluene etc. Some of these VOCs are also released from solvents/paints. We will note the source from gasoline station in the revised version. Specifically, line 24 will read as "also due to the control of the usages of paints and solvents and of evaporation from petrol stations."

"(4) As to the discussion of regional transport of ozone, I suggest the possible transport of ozone precursors need to be mentioned."

Reply: We will add the CO result (see attached new figure 7) and note other ozone precursors.

"(5) In conclusion, again, the episodic 190 ppbv ozone were found, the reviewer suggest the authors put together the site.

Reply: We will add "at an urban site" in the sentence.

Reply to referee 2's comments

"I would like to have seen the intersite comparisons include more rigorous statistical testing to determine the significance of the differences beyond the testing the significance test in Table 1 comparing different years."

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Reply: We will include the results of significance testing in all comparisons.

(2) page 12441 line 12 and figure 2. Why are the data uncertainties shown as 1/3 of the standard deviation? Based on these results it seems that the full standard error would be equal or in excess of the mean values, suggesting that the differences are probably not significant. It would be more useful to present these data in a format like box and whisker plot that provides a simple summary of the the probability distribution but is still fairly compact like the barplots used here. Seeing the range and values for mean median and selected quantiles (e.g. 25% -75%) would be more informative than having only the means. Same thing for Figure 3. Make sure the figures and sentences referring to them specify which site is being presented.

Reply: We used 1/3 of the standard deviation in Fig. 3 and 4 to improve the readability of the figures; we will use 1/2 of standard deviations in all relevant figures.

The suggested use of Box and Whisker plot is a good one. Because there are much few samples in Fig. 4 (for VOCs), it is difficult to make such a plot. Therefore we would like to retain the barplots in Fig 3 and 4 to focus on the mean concentrations in the three periods. (Fig. 2 and Fig 3. that you have mentioned is Fig 3. and Fig. 4, respectively.) The variation of the concentrations in the three years can be illustrated in the time series plot (Fig 2). We will add the info. on the significance testing when comparing the means of the data, as follows.

For the comparison of O3, NOy, sulfate, and nitrate shown in Fig. 3, the differences between period 1 and 2 (and between period 2 and 3) are all significant (T-test: $p<0.01$), and the ozone difference between period 1 and period 2 is significant at $p<0.05$. For the NOx in Fig. 4a, the differences between period 1 and 2 are all significant at $p<0.01$ for rush hours, day time and whole day, while the difference between period 2 and 3 were insignificant. For the VOCs shown in Fig 4b, the levels of significance were lower ($p> 0.05$) partly due to the much smaller number of samples.

In sum, the difference in the mean concentrations between period 1 and 2 for ozone,

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sulfate, nitrate, NOx, and NOy were statistically significant at $p < 0.05$. Although the differences in the VOCs in the two periods had lower significance levels, with the reference to the results by other researchers on VOCs and emission, it can be concluded that the VOCs levels were also reduced at our site. We will add these results in the revised manuscript.

The entire discussions in Section 3.1 are based on the results from the CRAES site, the site info will be added in figure caption for Fig. 3 and 4.

"(3) Pg. 12441 line 25. Comparisons such as this one stating that average values increased by some percent after implementation of full controls need to be evaluated for statistical significance. This is where having a representation of the distributions in the figures would be helpful. Even better would be to show the probability distributions for these pollutants before and after controls were implemented. Considering that the bars showing standard deviations divided by 3 are overlapping I suspect that the means are not significantly different and the comparison as presented here does not support the conclusion that the control measures were not sufficient. Instead, showing in the figure that the extreme values representing pollution episodes did not drop would support the statement that control measures were not sufficient to eliminate episodes.

Reply: Please refer to the response to comment 2. Both mean and peak values did not drop after control measures.

"(4) To what extent might the absence of a drop in ozone despite reduction in emissions at the CRAES site be explained by the well-known problem that ozone at urban core sites goes up when NOx is reduced because there is less Ozone titration?"

Reply: Available data suggest there were larger emission reductions in reactive VOCs than in NOx in the summer of 2008 in Beijing. Thus the pollution control before the Olympics is expected to reduce the production of ozone from emissions in Beijing. The increased ozone concentrations are mostly likely due to transport of southerly air masses. The following paragraph will be added:

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Interactive Comment

"Was the observed increase in ozone concentrations after the full control a result of decreased titration by NOx? Both ambient data (Fig. 4 of the present study) and emission inventory (Wang et al., 2010a) indicate a larger reduction in the emission of reactive VOCs than in NOx after July 20. The control measures are expected to reduce the production of ozone from Beijing regardless whether the ozone formation is controlled by VOCs, NOx, or both. Therefore, the observed increasing (both mean and peak) ozone concentrations must be due to other reason(s)."

"(5) Page 12444, lines1-5. The estimation of contribution from regional sources needs some clarification. Perhaps there are missing words in the sentence. I think this section is saying that ozone at the upwind site is on average already 62% of its peak value, implying that added emissions between the upwind site and Beijing contributed another 34%. Is that what you mean here? The comparison to downwind site is a very nice demonstration of the transport lag and a bit of dilution. The timing of the ozone peak at this site compares well with the mean diel patterns for nearby Miyun site reported by Wang,Y. et al. 2008, ACP, 8,6355."

Reply: Yes, we will add a clarification. "This implies that added emissions between the upwind site and the Beijing urban site contributed another 36% on average, demonstrating the important regional contribution. . ..".

The timing of the ozone (and CO) peak was similar to that in our previous study in 2005 at the downwind site and to that observed at Miyun by Y. Wang et al.

"(6) Line 7, how can the contribution from titration be distinguished from deposition depleting a shallow nighttime inversion layer as the cause of low ozone at the upwind site? Strong nighttime inversion layer would also contribute to elevated CO at night, without needing to have very large emissions. However, mean CO values throughout the day of 700 ppb are an indication that combustion sources are abundant near XCC. It would strengthen the point that upwind sources are important contributors of CO by including CO for the CRAES and downwind sites if available to show what fraction of

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the CO is already present upwind of Beijing."

Reply: We agree that the deposition could be another reason together with the NOx titration. Because of the addition of a new figure on CO, original discussions will be modified.

The CO data at CRAES were recently available to us. We have plotted the average CO diurnal profile for all three sites during the eight ozone episodes. As expected, the mean CO concentrations at the upwind site accounted for significant fractions (69-91%) of those measured at the urban site, which is consistent with the ozone data suggesting the importance of the regional sources. Fig 8. will be replaced with this new figure (see attached file). The following paragraph will be added in the revised version.

"The same diurnal plot for CO (Fig 7b) also reveals strong regional contribution of primary pollutant like CO (and possibly other ozone precursors). The mean CO concentration at the upwind site was 69-91% of that at the urban site during morning and early afternoon."

"(7) Page 12447 line 15. Can you include a citation for the suggestion that NOx emissions increased from 2005 to 2007? There has been considerable discussion about rapid increases in NOx emissions in China that there should be a good citation giving an estimate of the rate of increase."

Reply: While there have been a lot of discussions on the increase in NOx in recent years, to our knowledge, there has been no published result that shows the actual rate of the increase during 2005-2007 in Beijing and the surrounding regions.

(8) Minor errors. Page 12438 Line 18, refereed should be refered page 12440 line 2; the statement "these data were obtained from Systems" seems to be missing something. Is Systems a thing, or is there some missing text?

Answer: The typo will be corrected. The statement "These data were obtained from

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Systems" will be changed to "These data was obtained from Global Telecommunication Systems."

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 12433, 2010.

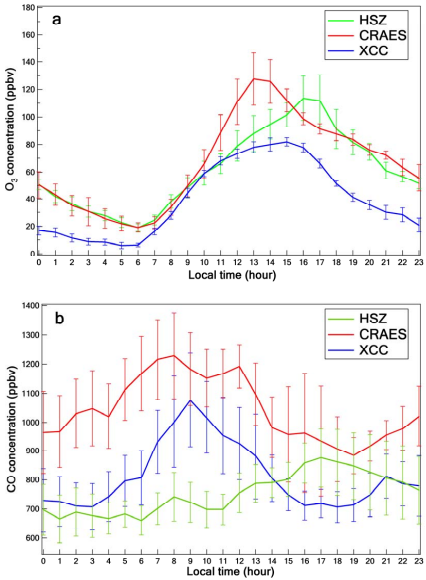

Figure 7. Average diurnal variation of (a) ozone and (b) CO at three sites for eight ozone-pollution days when southerly winds prevailed. Vertical bars are half standard deviations.

Fig. 1. New Figure 7 with CO

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