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Interactive Comment

Interactive comment on "Characteristics of trace gaseous pollutants at a regional background station in Northern China" *by* Z. Y. Meng et al.

Z. Y. Meng et al.

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We would like to thank both anonymous referees for their comments and helpful suggestions. We have revised the whole manuscript according to their comments and suggestions.

Response to comments by referee #1

Anonymous Referee #1

General comments:

Global chemical transport models have been suffered from lacking observational data set from Asia, especially from China to evaluate the performance of various models. Long term and trends of both gaseous and aerosol species in China are even more limited. This paper presents a good data set for one of the Chinese observation stations

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for the period of 2003 to 2006. Besides, the paper also presents the diurnal variations of various gas species, which are valuable for model evaluations. Therefore, I found this paper having a value to provide the modeling community the background concentrations of various gases in China and their trends and seasonal variations. However, there are a number of issues that need to be addressed before its final publication in ACP.

Specifically:

(1) The authors presented the trends and seasonal variations in the paper and used very speculative ways to explain the reasons. For example, in page 8, the reasons listed in the paragraphs can be applied to any situations. If any of those reasons was true for the SDZ station, why used observed meteorological data to support them.

Answer: We have revised section 3.2 according to the comments with adding more discussions. We have deleted the paragraphs in page 8 and Table 4.

(2) The paper compared extensively the ozone and other gas measurements with other locations around the globe. Except to state the highs and lows, there are no scientific messages from the comparisons. What does the paper try to convey?

Answer: We have rewritten this part and Table 3 according to the comments, as follow:

To help characterize the chemical environment of the study region, the data from SDZ station were compared with the measurements made at other two WMO/GAW background sites in China as well as abroad sites at similar latitude (Table 3). The Shangdianzi, Lin'an and Longfengshan stations are located in quite different regions in China (Fig. 1). The Shangdianzi station represents Northern China with developed economics and high populations. The Lin'an station is situated on the southern edge of the Yangtze Delta Plain, which is a densely populated and fast developing region. Longfengshan is a remote site in China's Northeast Plain, a sparsely populated and underdeveloped region. The observation of trace gases in Lin'an and Longfengshan stations has been conducted since July 2005. As presented in Table 3, the mean monthly O3 concentrations at SDZ are lower than those measured at Ryori, Janpan (23.1-56.9 ppbv). These concentrations are comparable to those observed at Lin'an, China (17.5-44.8 ppbv), Longfengshan, China (25.2-47.3 ppbv) and Trinidad Head, USA (22.7-44.9 ppbv).

The mean monthly NO2 concentrations at SDZ are higher than those measured at Longfengshan, China (0.9-8.8 ppbv) and Pleven, Bulgaria (1.1-19.1 ppbv), but lower than those measured at Burgas, Bulgaria (1.6-43.0 ppbv). These concentrations are comparable to those observed at Lin'an, China (6.6-24.0 ppbv). The monthly mean SO2 concentrations at SDZ are higher than those measured in Longfengshan, China (0.4-5.8 ppbv), but lower than those measured at Lin'an, China (8.6-2.7.1 ppbv), Burgas, Bulgaria (0.4-19.5 ppbv) and Pleven, Bulgaria (0.4-37.4 ppbv). The mean monthly CO concentrations at SDZ are higher than those measured at Longfengshan, China (169-591 ppbv) and Ryori, Janpan (96-235 ppbv), but lower than those measured at Lin'an, China (501-948 ppbv). As primary pollutants, SO2, NOx and CO concentrations at SDZ were higher than those measured at the Longfengshan station, China, but were lower than or comparable to those measured at the Lin'an station, China, reflecting the difference in the regional pollution in China.

(3) The diurnal variations of gas pollutants were discussed in the paper. However, the discussion was mixed with seasonal variations. Again, the explanations were all speculative. For example, when the SO2 diurnal variation was discussed, it was found that the SO2 concentration remained almost steady from 1800 to 2400 in the winter. The paper then attributed this to the higher energy demand for heating. The heating demand may be one of the reasons but not the only one. If a statement was made in a paper, scientific evidence should be provided. There are quite a number of places where similar statements were made without any proofs.

Answer: Hao et al. (2005) reported that the most important emission contribution of SO2 were domestic heating, industry and power plants. Area heating and industrial

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emissions were major sources, contribution 39% and 36% of the SO2 concentration in urban areas of Beijing. It was found that nocturnal temperature inversions and calm wind conditions played an important role in higher concentrations in Beijing (Meng et al., 2008). The concentrations of remain almost steady from 18:00 to 24:00 BST in winter at SDZ, which may be attributable to the sources of local and urban plumes transport to the measuring site.

(4) The paper is not well organized to present the results and sometimes it is very difficult to understand. This is a rather lengthy paper but the message from it is rather confused. I suggest a major over-hall of the paper structure and polish the English usage.

Answer: We have revised the whole manuscript according to the comments. For example, Abstract has been revised as follow:

We present measurement results of trace gaseous pollutants obtained at the Shangdianzi (SDZ) WMO Global Atmosphere Watch (GAW) regional background station in Northern China, from September 2003 to December 2006. The gases include ozone (O3), nitrogen oxide(s) (NOx = NO + NO2), sulfur dioxide (SO2), and carbon monoxide (CO). The data of trace gases collected at SDZ are representative for the regional background of North China Plain. As primary pollutants, SO2, NOx and CO concentrations at SDZ were higher than those measured at the Longfengshan station, China, but were lower than or comparable to those measured at the Lin'an station, China, reflecting the difference in the regional pollution in China. The concentrations of O3, NOx, SO2, and CO at the SDZ background station are found to have clear seasonal and diurnal variations. The back trajectory's analysis suggests that the elevated concentrations of O3 and CO are accompanied by the transport from the southeast direction of SDZ during May to September, and the highest SO2 and NOx levels are found for clusters coming from west of the site in November, December and January in 2006.

Response to comments by referee #2

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Anonymous Referee #2

This paper reports results of trace gases measured in the North China during 2004-2006. The seasonal cycle, diurnal variation and long range transport of air pollutions were investigated using some general data analysis techniques. However, in current form this paper is not well-organized and well-presented, and there are no any new/important scientific findings. Therefore, the referee cannot recommend it to be published in ACP. My main comments are listed below: 1.This manuscript looks more like a data summary/report but not a scientific article. In many paragraph in Section 3 (e.g. Page 9409-9410, page 9412 and 9417), the authors tried to repeat all results shown in tables and figures but without a more summarized discussions or conclusions.

Answer: We have revised the whole manuscript according to the comments. For example, we have revised this section according to the referee's comments with adding more discussions and so on.

2.About the influence of biomass burning activities in summer, is there any evidences (like chemical signature of CO/NOx and CO/SO2 ratio, or satellite data) supporting this conclusion? For this issue, the referee actually doubts about the quality of CO data measured in summer 2006. Fig 2 shows a board summertime peak of CO, but very low NOx and moderate O3 concentration. These results cannot suggest a possible source like biomass burning, which could also cause a high O3 and NOx. Meanwhile, Fig 4 shows that CO was about 700-800 ppbv in summer but almost without any diurnal change. This pattern is a little strange for such kind of rural station downwind of the polluted Beijing area. The referee believes that the local wind should have strong diurnal variation because of the complex terrain there.

Answer: There are some evidences about the influence of biomass burning activity in summer (Ding et al., 2008; Wang et al., 2002; Yan et al., 2008).

To examine if there was an unusual source of emission contributing to the June O3 maxima in Beijing, such as open-field burning of crop residues, Ding et al. (2008)

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analyze the monthly mean tropospheric NO2 column retrieved from Global Ozone Monitoring Experiment (GOME) during 1995-2002 and SCanning Imaging Absorption spectroMeter for Atmospheric HartographY (SCIAMACHY) satellite data for June during 1995-2005, and the Along Track Scanning Radiometer 2 (ATSR-2) total fire count maps during 1996-2005. They suggest that biomass burning contributes about 20% of the NO2 column in June over Beijing, indicating an important impact to ozone from the agricultural burnings activities.

Wang et al. (2002) showed that the very intensive biomass burnings in June were mostly related to the harvest of wheat in the North China Plains and East China. Besides the reducing tropospheric NO2 column in August could also be due to a faster removal of NO2 via hydrolysis and direct rainout under more humid conditions in that month (Ding et al., 2008).

An increase in median CO levels with O3 levels drop from June to July was also observed at a rural site north of Beijing in summer 2006 (Wang et al., 2008), which are attributed to the influence of the summer monsoonal circulation that develops over the North China Plain in July. Wang et al. (2008) found that photochemical production of O3 is reduced as a consequence of increased cloudiness during July and August, as indicated by the strong negative correlation observed between O3 and satellite observations of cloud optical depth, with cloudiness having little effect on CO.

The diurnal variation of CO in SDZ is similar to those measured in summer 2005 at a mountainous site about 50 km north of the center of Beijing (Wang et al., 2006), which are attributed to mountain-valley breezes transporting urban plumes to the north.

We have added the above information in our revised version.

3.For the long-range transport part (Section 3.4), why only one year 2006 was chosen for the trajectory analysis? Do the authors think the year 2006 is more climatically representative? However, the seasonal patterns of trace gases (Fig 2) do not support this point but show an abnormal seasonal cycle of O3 and CO in 2006 compared with other

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years. So if the authors want to address a general long-range transport characteristics using trajectory cluster analysis, it would be better choosing a representative year. Otherwise, they should focus on the possible impact of change in long-range transport to the abnormal seasonal patterns of some species.

Answer: Form Table 2, it can be seen that there was year-to-year difference in total number of valid data recorded, with the most data collected in 2006, especially CO concentrations. Although the data of gases and back trajectories for 2006 presented in paper, the air mass trajectories in 2004 and 2005 exhibit similar trends.

4.About the cluster analysis, is it really necessary to classify the trajectories into 14 categories? The authors should consider the statistical criterion to choose appropriate cluster numbers. In fact, some trajectory categories show similar pathways (refer to Fig.5) and the trace gases concentrations neither show significant difference (Table 6).

Answer: To help interpret hourly average concentrations of gaseous pollutants associated with each cluster of backward trajectories in 2006, it is necessary to classify the fourteen different clusters of various back trajectories. Although some trajectory categories show similar pathways, the monthly occurrence frequency of each category is different, for example: Cluster 1, 2 and 3 are from the west sector of the site, and these air masses pass through Huhehaote, Zhangjiakou and so on, which are industrial cities in Northern China. Cluster 1 has the second highest height and the lowest frequency of all air mass clusters. Cluster 2 occurs in January, February and December, giving rise to the elevated concentrations of primary gaseous pollutants observed at the SDZ site. Cluster 3 is observed mainly in the periods from January to April and October to December with the highest frequency in November.

5.About the wind rose analysis and diurnal change part in the discussion, the authors should be aware that the same results have been included in another paper in ACPD (by Lin et al., 8, 9139-9165, 2008).

Answer: We present measurement results of trace gaseous pollutants obtained at the

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Shangdianzi regional station in Northern China from September 2003 to December 2006, the companion paper written by Lin et al. (2008) focus on variations of surface ozone at the SDZ station during 2004-2006. Both papers present the good data set for one of the Chinese WMO/GAW background stations, which are valuable for model evaluations.

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