## C2354:

## General:

The authors use hourly observations of visibility, relative humidity RH, and wind speed and direction in 1999-2007 and daily observations of PM10 index, RH and visibility in 2005-2007, to study the trend in visibility and its diurnal and monthly variability in Beijing. The show a close association between the visibility variations and the changes in relative humidity and PM10 index, and also for different wind directions. The downward trend in visibility is explained by the increasing RH trend, despite reported decrease of PM10 index. For a August month (the month in which the 2008 Olympics were held in Beijing), the authors also look at the combined effect on visibility of PM10 index, RH, wind speed and direction for the period 2000–2008, demonstrating an improvement in visibility in the August 2008. Based on obtained results, the authors make a rough estimate of the value of PM10 index which should have been obtained in order to attain "good" visibility during 2008 Olympics (4-24 August). They conclude that both traffic and industrial emissions needed to be restrained for this purpose. **Response:** Thank you very much for your comments.

**<u>Response</u>**. Thank you very much for your commen

# Major comments:

1) rather different length of time-series of visibility and PM10 data the conclusions are based one; probably the authors could look closely at the period 2005-2007, for which both visibility and PM10 (and RH) data are available (besides PM10 variation in 2005-2007 is not presented).

**<u>Response</u>**: As the inconsistence of the Beijing API data being mentioned in Andrews's paper, we try our best to collect the API data of every observing station in Beijing to recalculate the result in Figure 4 and Figure 7. The data we have include daily API for 28 stations from 2003 to 2009. Because of some unexpected and historical reasons, for instance, some data are lost, some stations were relocated and some were established after 2006 during this period, not all stations have the complete records of API for 7 years. In this reply, we chose 19 stations with complete observations from 2003 to 2008 (Figure

1a). Daily mean API is calculated. If there is a day in which API record of more than 3 stations are missing, the day is regarded as an invalid day. If invalid day in a year is more than 30 days, that year is an invalid year. Data in an invalid day are not considered in our analysis (figure I b). There are 52 invalid days in 2007, so we did not give the mean API in 2007 in figure II. Annual API is decreasing from 2003 to 2005 and there is an increase of API in 2006. But summer API continues decrease from 2003 to 2006. Since the limit data sample, we did not calculate trend.



Figure I. a) 19 API observing stations in Beijing. b) Time serials of data availability of 19 stations. Blue line denotes valid day. White lines (blanks) represent invalid days.



Figure II Annual variation of API of PM10 in a whole year and summer season from 2003 to 2006 and 2008.

2) It could be advisable to show the variation of PM10 index, discussed in the manuscript. Furthermore, according to Andrews (Environ. Res. Lett., 2008), reported improvement in PM10 concentration in Beijing for 2006-2007 can be attributed partly to a shift of monitoring stations in 2006 to less polluted areas. Could the authors, please, comment on that.

**<u>Response</u>**: Due to the inconsistency of data, what we can show is the variation of mean API of 19 stations from 2003 to 2008. The result based on the 19 observing stations in this reply (shown in Figure III) is very similar to that based on whole-city PM10 index in our paper (figure 4 & 7). Missing data of the 19 stations could also cause some degree of the difference between Figure III and Figure 4 in our ACPD manuscript. From this comparison, we think the data inconsistence caused by the shift of a few monitoring stations dose not affect our results significantly.



Figure III. (a) Daily mean visibility of BCIA vs. daily mean PM10 concentration in Beijing from 2005 to 2007 using the 19 observing stations. The correlation index between visibility and  $\ln(PM10 \text{ concentration})$  for four seasons is shown as the variable "*r*".

(b) Daily mean visibility distribution in relation to RH,  $PM_{10}$  index, wind speed, and wind direction for August from 2003 and 2008 in Beijing. Blue symbol represents visibility lower than 5 km, green symbol represents visibility lower than 10 km and no less than 5 km, cyan symbol represents visibility lower than 20 km and no less than 10 km, and red symbol represents visibility no less than 20 km. The symbols with "+" represent observation in 2008. Triangle represents wind speed lower than 1.5 m s<sup>-1</sup>, circle represents wind speed greater than 1.5 m s<sup>-1</sup> and lower than 3 m s<sup>-1</sup>, and square represents wind speed greater than 3 m s<sup>-1</sup>. Hollow symbols represent wind directions of south, southeast, east, and southwest. Solid symbols represent wind directions of northeast, north, northwest and west. The black solid lines denote the visibility

contour of 5 km, 10 km and 20 km.

3) chemical composition of PM10 (as PM soluble components, namely SO4, NO4 and NH4, determine the PM hygroscopic growth with increasing RH); the major sources of the soluble inorganic aerosols in Beijing, as limiting those may decrease the deterioration of visibility with increasing RH; PM10 size distribution (in particular the fraction of particles with sizes just below the visible wavelength, as their growth with RH contributes the most to visibility deterioration);

**<u>Response</u>**: Yes, We agree that the physical and chemical properties of aerosol will affect visibility deterioration. To study the change of that effect in a region, especially annual variation, is very complicated and also needs intensive observations of both microphysics and chemical constituents. But we don't have the long-term observing data, such as the size distribution and chemical composition of aerosol. We add a brief discussion about the impact of chemical and physical properties on visibility in the manuscript.

4) the latter is also connected to the choice of PM10 mass as indicator of the amount of light scattering aerosol in air, which the authors explain that fine PM2.5 account for 99% of PM10 in Beijing (ref. Shi et al., 2003). But according to Shi et al. (2003), it applies to the number of fine PM, but not the mass, and the mass and number concentrations are not always correlated.

**<u>Response</u>:** We agree. Text revised. Thank you.

5) representativeness (or its lack) of in-citu PM10 measurements for such a horizontally averaged parameter as visibility (see e.g. Baümer et al., 2007). In fact, there is no what so ever description of PM10 monitoring sites used in the manuscript.

**<u>Response</u>**: Thank you. We add the description of PM10 monitoring sites (figure I(a) in this reply) to the revised manuscript.

## Specific comments:

1) Abstract (and else where): Since 'decreasing PM10 trend' is not shown in the present work, please give the reference.

**<u>Response</u>:** Thanks. Text revised. (The decreasing trend of PM10 in Beijing during the period of 1999-2005 is shown in the figure 4 in Chan and Yao's paper (Chan, C. K. and Yao, X.: Air pollution in mega cities in China, Atmos. Environ., 42, 1–42, 2008). We have cited it in the Introduction. Here we also add it in the Abstract. The paper also shows the downward trend of soot and SO2 of Beijing during 1998-2005.)

2) check on the use of tenses when referring to the past (e.g. 'should have been' instead of 'should'. 'returned' instead of etc. 'has returned').
<u>Response</u>: Text revised. Thank you.

### 3) Last sentence: explain 'the same period of 2009' and 'standard'.

**<u>Response</u>**: Text revised. The same period denotes the period of August 8<sup>th</sup> -24<sup>th</sup>. The "standard" means the average blue-sky-hour rate (red dashed line in Fig. 8). It can read from Figure 8 that the blue-sky-hour rate of 2009 is about 18%, which is around the average blue-sky rate - 19.5%.

#### 4) 1. Introduction:

line 20 and else where – change 'decreased trend' to 'decreasing trend' or downward trend'

# line 27 – at Beijing.. airport

line 28 – it's not relevant to talk about 'respirable particles', but rather 'fine fraction' line 29-30 – it should be pointed out that according to Shi (2003), fine PM contribute with 99% to PM10 number, not mass. The details on measurements data used (l. 24-28) should be moved to section 2 'Data description'

**Response:** Text revised. Thank you.

#### 5) 2. Data description

The authors are advised to collect all spread details about measurements in this section and give a better structured data description, including details about PM10 monitoring network (e.g. number and type of the sites). **<u>Response</u>**: Thanks. We agree. A figure are added to the revised manuscript and also detail description are added in the section 2.

6) l. 9-10 – 'data on/for', or 'visibility data'

**Response:** Text revised. Thank you.

7) line 13 – explain 'PM10- a leading pollutant'

**<u>Response</u>**: It means the primary pollutant. In Beijing, PM10 is usually the major air pollutant reported.

8) *line 14 – 'presented' instead of 'measured'* 

**<u>Response</u>**: Text revised. Thank you.

9) 3. Results and discussion

3. Results and discussion Please, check that the past tense is used when referring to the past p.6203, 22 – suggested: The monthly variation of RH shown in Fig.3 reveals that the moisture abundance in summer.....

**<u>Response</u>**: Text revised. Thank you.

10) p.6203, 27 – suggested 'in addition' instead of 'on the other hand'
p.6204, 2 – 'On average' instead of 'In general' 8 – increasing trend of RH
Response: Text revised. Thank you.

11) p.6204, 16- 'The days .. are excluded'. Also, could you please give a brief explanation why.

**<u>Response</u>**: We want to avoid the influence of precipitation and fog weather to the visibility observation, just as many other similar works. (For example, in some works, visibility observation are excluded in analysis when RH is greater than 90%. Chang, D., Song, Y., and Liu, B.: Visibility trends in six megacities in China 1973–2007, Atmos.Res., 94, 161–167, 2009.)

12) p.6204, 20-22-Suggested: The visibility varies between 2 km and 45 km when PM10 index is below 100, and most of the days with.... occur in summer.

23 – suggestion: combined frequency distribution of visibility ranges and RH
 Response: Text revised, Thank you.

*p.6205, 8 – increase light extinction* **Response:** Text revised. Thank you.

13) p.6205, 9 – "This explains' seems is too determined. What about 'We think it is a probable explanation'

**Response:** Text revised, Thank you.

14) p.6205, 14- characterize the transport 19 – remove 'also'
24 – 'visibility is associated'
25 - 'regional transport of less polluted and moist air from...' **Response:** Text revised. Thank you.

15) 3.3 Visibility in August The discussion in this section is rather messy and needs better structure. It would also be nice to have a clear explanation why the authors specifically focus the discussion on the August month (and further 8 to 24 August in fig.8) in 2008. **Response:** We agree. We have added a short description in discussion.

16) p. 6206, 3 – remove the repeated 'observations', and explain 'as verification' (of what)?
8 – Its (?) PM10 – explain. Probably 'PM10 in the same period...'
Response: Text revised. Thanks.

17) p. 6206, 10 – 'brought more challenge'
11 – 'was impossible' and correct for the past tense through the rest.
13-14- The sentence starting with "Improvements..." should be moved in Introduction.
Response: Text revised. Thanks.

18) p. 6206, 15-16 – please, re-formulate/explain that "vehicle emissions contribute with 24% in a wet season'. Do people drive more in a wet season?

**Response:** No, it is because other emission such as soil dust may vary from wet season

and dry season, and that will affect the relative contribution of car emission.

19) p. 6206, 17 – what is 'secondary biomass burning'?

**<u>Response:</u>** Thanks. It should be "secondary pollutants, biomass burning". Text revised.

20) p. 6206, 27-28 – 'decrease of PM10 and increase of visibility compared with other symbols' is an unfortunate formulation; "compared to observations in 2000-2007"?

**Response:** Thanks. That sentence has been changed to "The symbols with "+" which represent observation in the August of 2008. Figure 8 show obvious decrease of daily PM10 index and increase of daily mean visibility in the August of 2008 compared with the August from 2000 to 2007.

21) 4. Conclusions – advisable to be tidied up.

p.6207, 11-13 – the first sentence should be better formulated.

18 – elaborate the general statement 'Topography plays an important role in blocking pollutant dispersion'

24 – 'apparently due to the increase in RH'

26-27 -should probably be 'a good day would not have happened during Olympics 2008 even

if all vehicle emissions were eliminated'

**Response:** Text revised. Thank you.

22) p.6207, 28 – what is 'secondary emission',......'should have also been considered'

**Response:** It should be "secondary biomass burning emission". Text revised. Thanks.

23) p.6208, 1 – 'The result was verified..' is a very unclear statement. Maybe it was more like 'some conclusions were confirmed'?

**Response:** Text revised. Thank you.