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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Possible influence of atmospheric circulations on winter hazy pollution in Beijing-Tianjin-Hebei region, northern China" *by* Z. Zhang et al.

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Dear Reviewer, We sincerely thank you for your positive and constructive comments and suggestions on our work; your comments substantially improved this paper. Our responses follow the "»" signs in the response file and are marked in the revised manuscript with the "track changes" mode in word.

1. The abstract is not only an overview; some important conclusions should be listed in this section. »Answer: Well, we added some important conclusions in the revised abstract, such as "In the raw (unfiltered) correlations, the correlation coefficients between

the six indices and the winter visibility (number of hazy days) varied from 0.57 (0.47) to 0.76 (0.6) with an average of 0.65 (0.54); in the high-frequency (<10 yr) correlations, the coefficients varied from 0.62 (0.58) to 0.8 (0.69) with an average of 0.69 (0.64). The six circulation indices together can explain 77.7% (78.7%) and 61.7% (69.1%) variances of the winter visibility and number of hazy days in the year-to-year (interannual) variability, respectively". Moreover, the possible linkage mechanism between the winter hazy pollutions and the circulations were also summarized in the revised abstract, such as "The increase of Ic (a comprehensive index derived from the six individual circulation indices) can cause a shallowing of the East Asian trough at the middle troposphere and a weakening of the Siberian high pressure field at sea level, and then accompanied by a reduction (increase) of horizontal advection and vertical convection (relative humidity) in the lowest troposphere and a reduced boundary layer height in BTH and its neighboring areas, which are favorable for the formation of hazy pollutions in BTH winter, and vice versa".

2. In this paper, the statistical relationship between the atmospheric circulations and visibility (hazy days) was discussed, which is significant for the pollution potential prediction. What is the authors' opinion about the long-term statistical forecasting of pollution? On the basis of the present research work, how to consider the long-term quantitative forecast of visibility and hazy days? »Answer: Well, the significantly statistic results derived from the long-term records showed that the links between the winter visibility (hazy days) in BTH and the circulations indices are stable over the past three decades. The diagnostic analysis results just suggested the findings can be used to predict or evaluate the winter hazy pollutions in BTH. Theoretically this should be fine since the common atmospheric circulation variables (including SLP, U850, V850, H500, U200 and T200 in this research) can be available from a variety of climate prediction modes, such as the seasonal climate predictions from the NCEP coupled forecast system model. According to the predicted circulation indices and the statistical models, we can quantitatively evaluate the possible changes of the future winter visibility and number of hazy days in this area. However, there are a lot of works need to be done

before running in the forecast operations. We need to choose the most suitable climate prediction mode for the given areas, to evaluate the stability and reliability of climate prediction data in describing the variability of the circulation indices in the history. Generally, the improvement of the level of climate predictions is very helpful to advance the prediction level of winter hazy pollutions.

3. The atmospheric circulation and pollutant emissions are the two major factors influenced visibility and haze days. A series of changes have taken place in the emission discharge from 1980 to now. How to consider the impact of the atmospheric circulation with removal of emissions? »Answer: Yes we think the pollutant emissions (such as particles, SO2, and NOx) varied more or less year to year over the BTH and it neighboring areas during the last several decades. According the records in statistical yearbooks of China and Beijing, the annual total energy consumption (million tons of standard coal) of Beijing, Tianjin and Hebei were shown in Figure S1, respectively. It can be seen that the total energy consumption in BTH regions increased distinctly during the last three decades. In view of the improvement of energy utilization technology, the increase of the total energy consumption does not mean an increase of pollutant emission. As shown in Figure S2, the total SO2 emissions in Beijing increased gradually in the 1980s and 1990s, but it decreased significantly during the last decades. The total soot emissions are similar to variations of SO2 emissions. The total industrial dust emissions decreased generally except an abrupt increase around 1998. Although there is no the accurate emission data in winter in the BTH region, we guess the emissions in winter are similar to the annual changes. However, the mean winter visibility (number of hazy days) did not decreased (increased) obviously or decreased (increased) first and then increased (decreased). Thus we speculate the inter-annual variability of the hazy pollutions (visibility and hazy days) may be more dependent on the meteorological conditions. On the other hand, due to the lack of enough awareness about environmental issues during the rapid economic growth and urbanization, the regional or even national emissions control was very rare during the past time, especially before the 2008 Olympic Games in Beijing. According the government's an-

nouncements and the related literatures (An et al., 2007; Zhang et al., 2010; Gao et al., 2011), we know the pollutant emissions over northern China around 2008 were controlled widely and strictly by the Chinese government in order to host the 2008 Olympic Games in Beijing, and then a similar control was carried out for hosting APEC 2014 in Beijing. During these periods, except the strict controls in Beijing, a lot of factories, constructions and traffics around the BTH region or even the whole northern China were temporary closed or limited. In view of this point, the winter pollutant emissions in BTH or even norther China over the last three decades may be roughly stable during the last three decades. In the view of the long-term statistic models, the influences of the possible minor changes of pollutant emissions may be secondary. Moreover, if there are dramatic changes in emissions caused by policy or other important events, we should split the entire periods into different stages and then build the different statistical models in operations. Assuming the pollutant emissions are same as usual in the future winter, an anomalous high Ic may warn that a severe hazy pollution is likely to happen. However, the coming hazy pollution will be alleviated partly if the government to take actions in controlling pollutants discharge. In this sense, the circulation indices are more indicating the winter meteorological conditions over the BTH region, which are conducive to the accumulation of pollutants and the formation of hazy pollutions or not.

Figure S1. Curves of the annual total energy consumption (million tons of standard coal) in Beijing (a), Tianjin (b) and Hebei province (c)

Figure S2. Curves of the annual total SO2 (a), industrial dust (b) and soot emissions (c) in Beijing

4. The number mark in the Fig.3, 4, and 6 is not very clear. »Answer: We re-plotted the Fig.3, 4, and 6, increased the font size and the intervals. Moreover, the Fig.3 (e) in the raw Fig.3 should be removed, and it has been corrected in the revised figures.

Figure 3. Spatial distribution of correlation coefficients between visibility and SLP (a),

UV850 (b), H500 (c) and U200 (d) (Area significant at the 0.05 level are shaded; either U850 or V850 significant at the 0.05 level are shaded in b)

Figure 4. Spatial distribution of correlation coefficients between visibility and T200 (a), T150 (b), T100 (c) and T70 (d) (Area significant at the 0.05 level are shaded)

Figure 6. The climatological mean fields of SLP (a) and H500 (b) averaged in winter 1981 to 2010, and the spatial distribution of the regression coefficients of SLP (c) and H500 (d) upon the Ic over the period 1981 to 2015 (Area significant at the 0.05 level are shaded)

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/15/C7076/2015/acpd-15-C7076-2015-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 15, 22493, 2015.

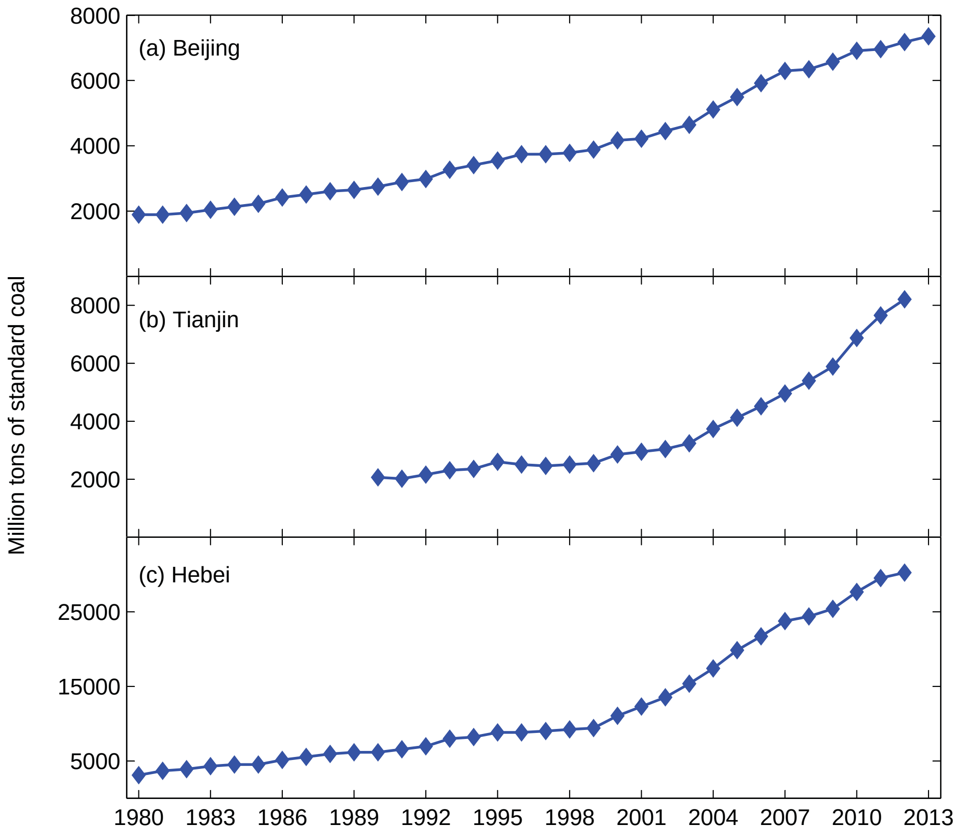

Fig. 1. Figure S1. Curves of the annual total energy consumption (million tons of standard coal) in Beijing (a), Tianjin (b) and Hebei province (c)

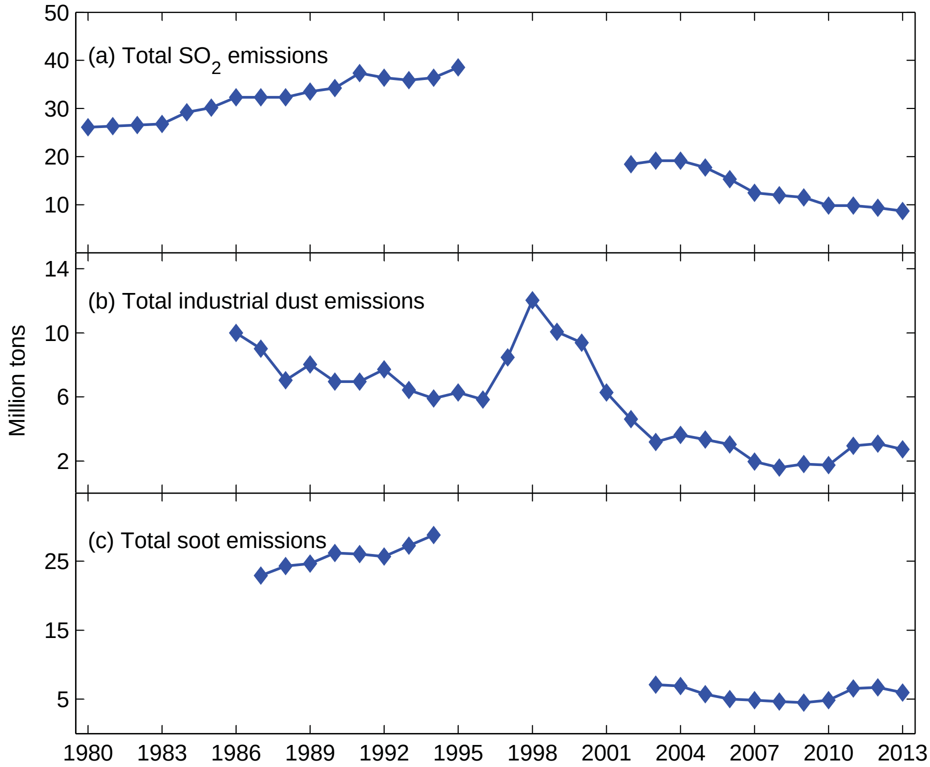

Fig. 2. Figure S2. Curves of the annual total SO2 (a), industrial dust (b) and soot emissions (c) in Beijing

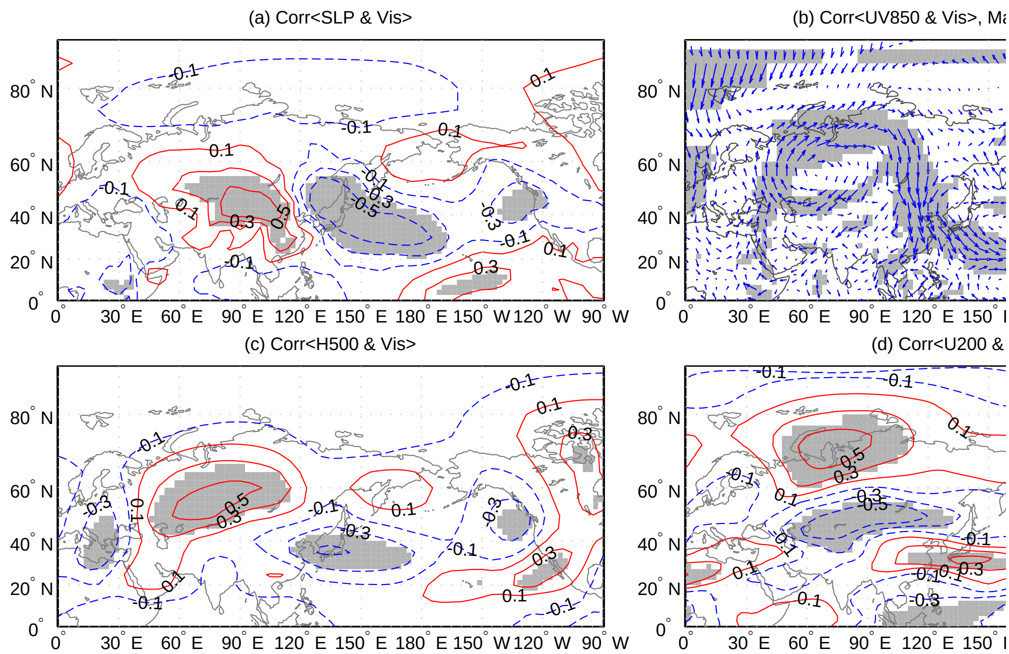

Fig. 3. Figure 3. Spatial distribution of correlation coefficients between visibility and SLP (a), UV850 (b), H500 (c) and U200 (d) (Area significant at the 0.05 level are shaded; either U850 or V850 signific

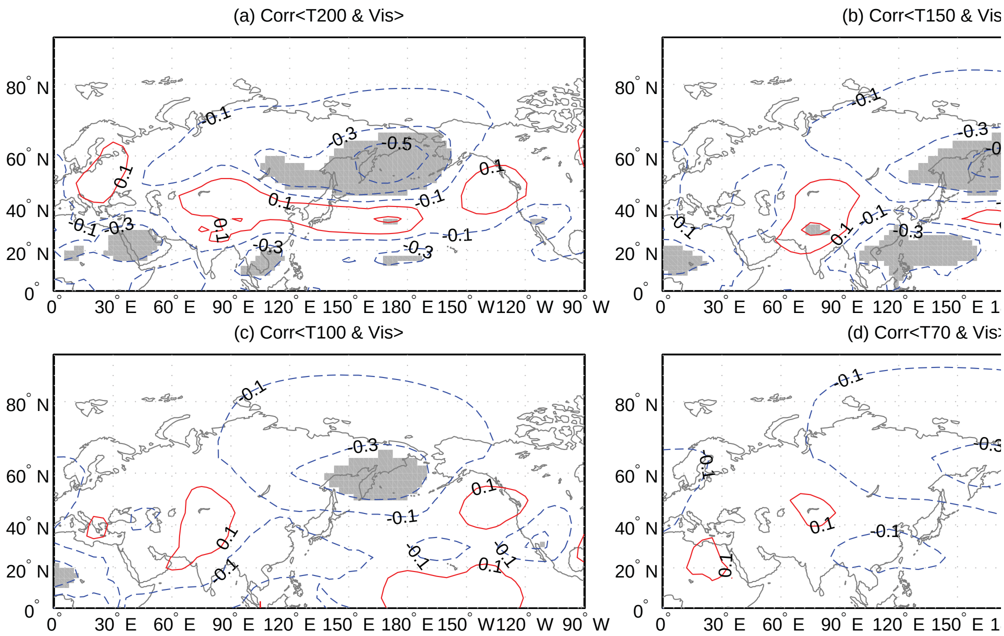

Fig. 4. Figure 4. Spatial distribution of correlation coefficients between visibility and T200 (a), T150 (b), T100 (c) and T70 (d) (Area significant at the 0.05 level are shaded)

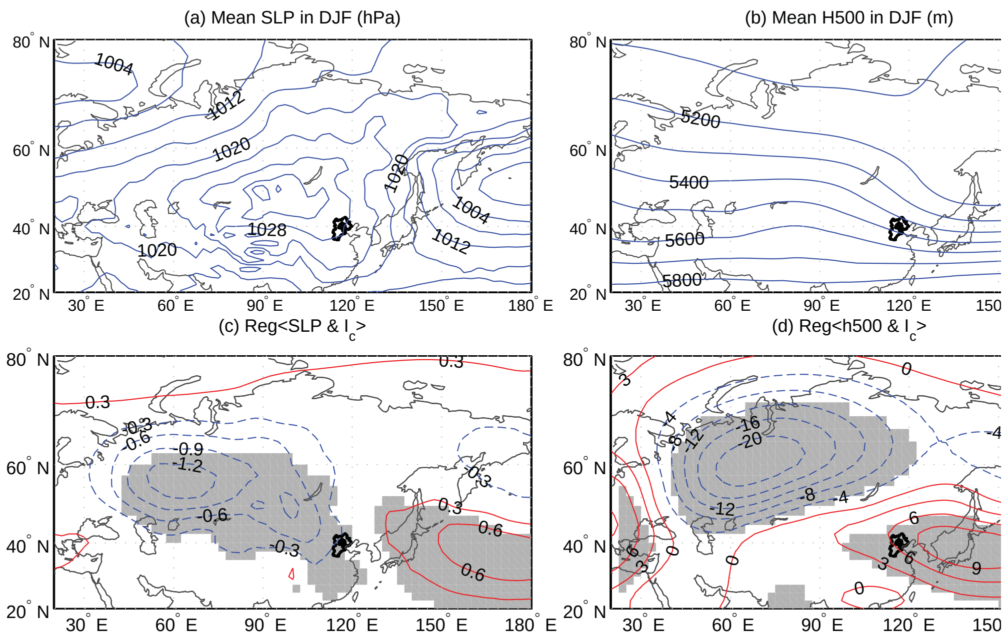

Fig. 5. Figure 6. The climatological mean fields of SLP (a) and H500 (b) averaged in winter 1981 to 2010, and the spatial distribution of the regression coefficients of SLP (c) and H500 (d) upon the Ic over t