7.9 COMPARISON ANALYSIS OF TWO CONTINUOUS HEAVY POLLUTION EPISODES IN BEIJING, CHINA

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1. INTRODUCTION

With the rapid development of urbanization, air pollution in urban area has become an important problem directly threatening to human health. All level governments and scientists have paid more and more attention to the urban air quality. In China, with the regulation of energy structure and high scientific and technological development and the execution of air pollution control, air quality was gradually improved. But the particle matter, especially fine particle matter and photochemical pollution are becoming serious in some large cities due to the large traffic emission, certain weather and climate condition and specific topography. So many scientists focused on this field about particle pollution and its composition(Ward et al. 2004; Bogo et al. 2003; Song et al. 2002), photochemical pollution and its formation mechanism (Lee et al. 2002; Xie et al. 2004), and the pollution impact on health (Stedman,2004).

Beijing city, as one of the metropolitan cities in China, located in North China. The north, northwest and northeast parts of Beijing area are mountain area, the southeast is plane area, the urban area is located in plane area. According to the observed concentration for air pollutants and the national ambient air quality standards, the major pollutant is the particle matter (now we have the PM10's standard for particulate).In 2004, there were two heavy air pollution episodes with very high concentration of PM10 and PM2.5 and low visibility, which happened from 6 - 10 October (Oct. episode) and 29 November to 3 December (Dec. episode). These two pollution episodes caused great impacts and damage on human health and social activities. In this paper, we analyzed the pollution's features of spatial and temporal distribution and as well as regional and local meteorological conditions, compared the similarities and differences for these two heavy air pollutions.

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2. CHARACTERISTICS OF HEAVY POLLUTION

During the two pollution episodes, the concentration of PM10 is very high in Beijing. From the SEPA daily report of air pollution index for Beijing and surrounding cities, we selected six cities of North China to compare the regional or local pollution for different cities during the continuous pollution. The six cities included Beijing, Tianjin, Shijiazhuang in Hebei province, Taiyuan and Datong in Shanxi province, and Huhehaote in Inner Mongolia. The figure 1 indicated that PM10 concentration in Beijing was much higher during the Oct. pollution episode. But in Dec. episode, high concentration of PM10 appeared in more than three cities. During the very polluted period, the maximum concentration of PM10 in Datong was higher than that in Beijing, but it only lasted two days. As the downwind area, Tianjin city also reported high concentration on Dec. 2 and Dec. 3. This features implied that first episode had more local air pollution characteristics and the second episode had region pollution features.

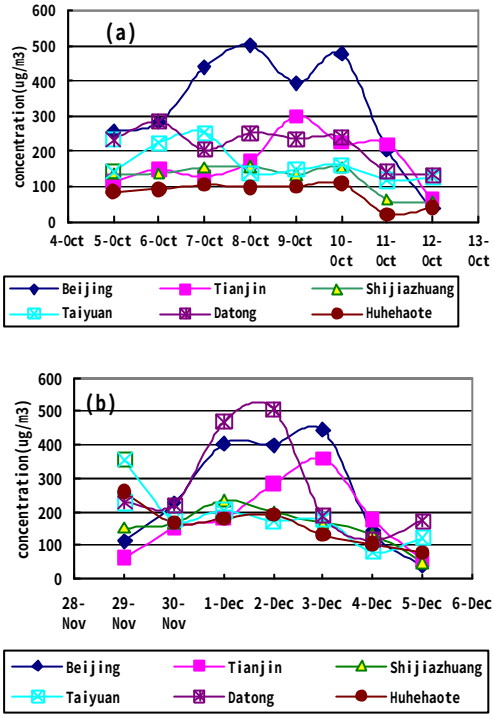


Figure 1: Daily average concentration of PM10 in Beijing and surrounding cities, (a) for Oct. episode, (b) for Dec. episode

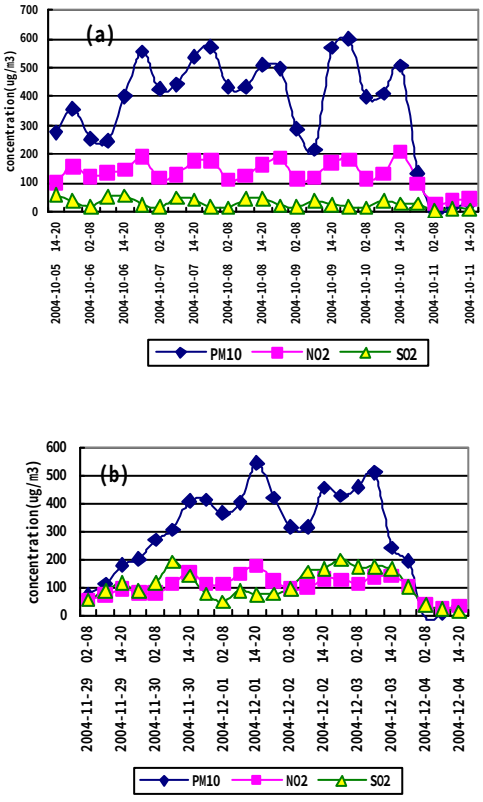


Figure 2: 6-h averaged concentration during two pollution episodes in Beijing urban area

Figure 2 is 6-hour averaged concentration for PM10, NO2 and SO2 automatically monitored in 7 stations from Beijing Environmental Protection Bureau. It exhibited the detailed variation features for different pollutants during the pollution period and the pollutant accumulation and dispersion. The observed data showed particle matter concentration maintained very high level in each episode. The high concentrations over 300μg/m^3 of 6-hour averaged lasted 4 days and 3 days in the first pollution episode(figure 2a) and second episode (figure 2b), respectively. The fine particle matter PM2.5's concentration was also very high from other urban station's observation in these two episodes. The other information can be seen that, in the first pollution episode, all these three pollutants concentration had clear diurnal change even for the very low concentration of SO2, and the concentration of NO2 was higher than in second episode. The diurnal variation and higher NO2 concentration were closely related to the local human activities and traffic emission. In the second pollution episode, the PM10 concentration was gradually accumulated and lasted three days, then quickly dispersed along the strong weather system across which will be discussed later. This give us further information that the first episode was a typical local air pollution event (clear diurnal change, relative high NO2 concentration, higher fine particle concentration) which took place in the urban or near suburb in Beijing and the second event had regional pollution feature (more homologous).

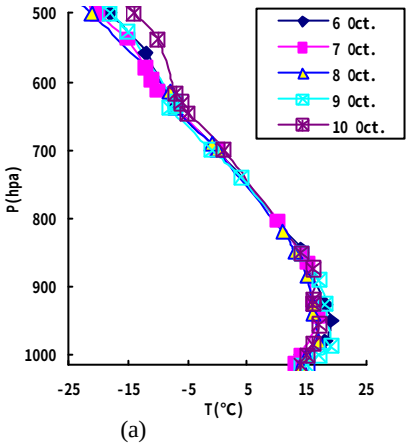
3. METEOROLOGICAL CONDITION

From the analysis of surface and high level weather situation, it can be found that during the both heavy air pollution episodes, the synoptic system and surface pressure were very weak over North China. Atmospheric

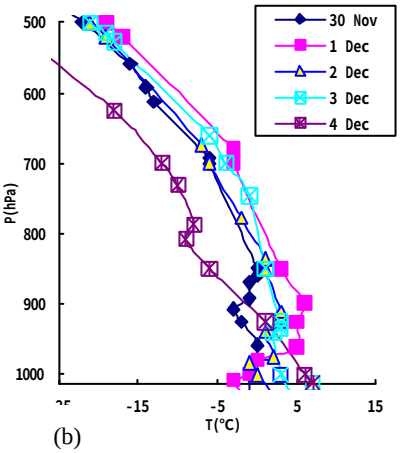
diffusion ability is very weak in local and regional area. The weather phenomenon during the first pollution event mostly recorded soot and haze, while fog and heavy fog occurred in the second event.

The sounding and surface meteorological data in Beijing were collected and analyzed here. In the first pollution episode from Oct. 6 to Oct. 10, vertical profile of temperature in the morning showed that very clear inversion maintained within boundary layer and very similar during the 5 days (figure 3a). This caused very stable boundary layer, decreased vertical convection activities and air pollutant could not be transported out of the inversion layer. For the second pollution episode, the vertical structure of temperature was more complex, inversion appeared near surface and low level from Nov. 30 to Dec. 3. Near surface relative humidity was very high (mostly larger than 80%) in two pollution episodes. The visibility was very low, most time less than 10km and sometimes even less than 100m in the second heavy pollution period. The weather reported fog and heavy fog during Nov. 30 - Dec. 3. There were also some differences for vertical structures of vapor and humidity. The wind was also weak near surface during pollution period. Figure 4 is surface wind rose distribution using 6 automatic weather stations data located in urban and suburban areas. The surface wind characteristics were, NE wind was the dominate wind direction in the first pollution period and the wind speed was very low. In the second pollution episode, the NE wind and east wind were the main wind direction and other direction wind also recorded more and larger than that in the first pollution episode. The calm frequency was 27% and 21% during the first and second pollution episode, respectively, the mean wind speed was 1.2m/s and 1.54m/s. During the first episode, there was a clear wind field convergence in urban area.

It seemed that, although there were some differences between the two pollution episode, all the weather conditions and meteorological elements (stable boundary atmospheric layer, low wind speed, weak turbulent diffusion, continuous inversion and high relative humidity) were very conducive to the high pollutants. It indicated the meteorological conditions played an important role in the formation of heavy pollution with help of local and regional pollution emission. At the same time, the strong synoptic system could destroy the inversion, generate large wind and strengthen convection activities, and increase the diffusion and dispersion ability for air pollutants.



(a)



(b)

Figure 3: Temperature vertical profile of 0800BST during the pollution period. (a) for Oct. episode, (b) for Dec. episode

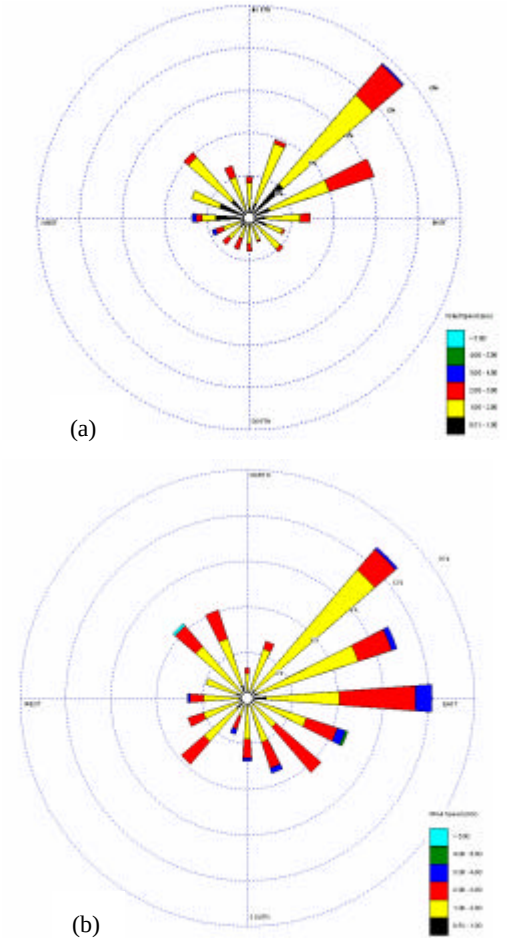


Figure 4: Surface Wind Rose Plot fir two pollution episode . (a) for Oct. episode, (b) for Dec. episode

4. CONCLUSIONS

From the above analysis, it showed that the first continuous heavy pollution was mainly caused by emission of local pollution source, weak synoptic system, stable boundary layer and the special topographic character in Beijing, the second continuous pollution was mainly made by regional heavy fog weather and stable boundary layer and is a regional air pollution episode.

The preliminary results showed that, (1) The Oct. pollution episode had more local air pollution characteristics which took place in the urban or near suburb in Beijing and NO2 concentration is a little higher, but regional effect should not be ignored either; (2)The Dec. episode had much more regional pollution features which high concentration reported in several adjacent big cities near surround Beijing. (3) PM10 concentration was maintained very high for long time. (4) The meteorological conditions were conducive to high pollution formation in both episodes, which showed very stable boundary layer, weak pressure, low wind speed, continuous inversion and high relative humidity; (5) Both local emission and regional pollutant transport contributed to the high pollution in Beijing.

5. ACKNOWLEDGEMENTS

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