STATE OF THE AIR QUALITY IN THE MAIN REGIONS OF PEARL RIVER DELTA

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ABSTRACT

In this study the current status of the ambient air quality in the main cities of Pearl River Delta region was investigated. Two special administrative regions (Macau and Hong Kong) and three major cities of Guangdong (Guangzhou, Dongguan and Foshan (I resort the order to be consistent with the later parts)) were selected for analysis according to their geographical distribution, population, gross domestic product and industrial importance. The air quality of each city was diagnosed by using the monitoring data of 2014 and by applying the HYSPLIT model. This region is found affected by transboundary pollution outside the Pearl River Delta but the local emissions are the most important. The Asian Monsoon system also influences the air masses transport pattern.

Keywords: air quality status, backward trajectories, Pearl river delta

1. Introduction

The Pearl River Delta (PRD) is located in the southern coast of China and it is the second largest delta of the country. It has a geographical area of about 8 000 km^2 comprised of nine municipalities of the Guangdong province and two special administrative regions (Macau and Hong Kong). According to the National Bureau of Statistics of China (2014) the gross domestic product of this region rose 32.0% between 2008 and 2012. Its rapid development resulted in the increase of energy consumption, the atmospheric emissions and the degradation of the ambient air quality. To implement measures for air quality improvement in this region, it is necessary to study the current state of its pollution, which is the motivation of this study.

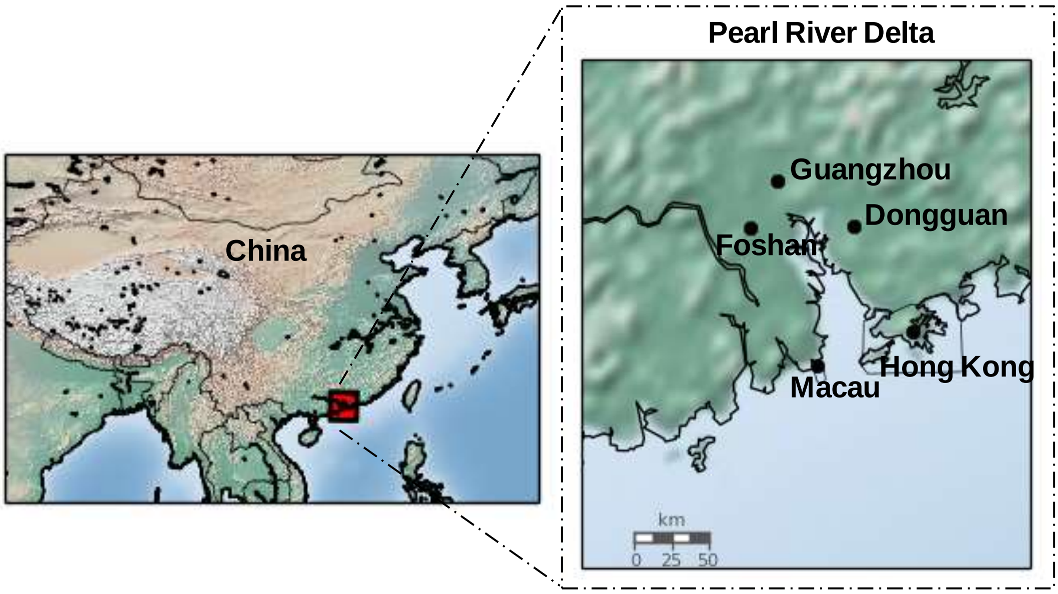

Figure 1: Map of PRD and its major cities.

The main objective of the present work is to investigate the current status of the ambient air pollution in the major cities of PRD chosen according to their geographical distribution, population, gross domestic product and industrial importance. Therefore, Macau, Hong Kong and three major cities of Guangdong (Guangzhou, Dongguan and Foshan) were investigated.

2. Approaches to analysis of data

In this work the data from 44 air quality monitoring stations (5 in Macau; 15 in Hong Kong; 11 in Guangzhou; 5 in Dongguan; and 8 in Foshan) were analyzed for the year 2014. The data of Macau and Hong Kong were obtained from the Macau Meteorological and Geophysical Bureau (SMG), and the Hong Kong Environmental Protection Bureau (HKEPD), respectively. For the other cities, the data were archived from the real-time air quality announcing platform of China. The air quality monitoring stations can be classified into four land use types: 1) urban area that represents densely populated residential areas mixed with some commercial and/or industrial areas; 2) new town that represents mainly residential areas; 3) rural area; and 4) roadside that is a combination of residential/commercial area with heavy traffic and surrounded by many tall buildings (HKEPD, 2013). The monitored pollutants include respirable/fine particulate matter (PM_{10} and $PM_{2.5}$), nitrogen oxides (NO_X including NO and NO_2), ozone (O_3), carbon monoxide (CO) and sulphur dioxide (SO_2). It is important to note that the concentrations recorded by air quality monitoring stations were compared with the China air quality standard (GB 3095-2012). To relate the air quality with the local meteorology, the meteorological data of these cities (wind, precipitation, temperature and sunshine) were also analyzed. The meteorological data adopted in this study were obtained from the National Climatic Data Center of NOAA, Macau SMG and HKEPD. Finally, the HYSPLIT model is employed to identify some plausible influence of local transport of emissions between these cities and the transboundary pollution outside the PRD according to the backward trajectories of air masses with different periods ranging from 1 to 2 days.

3. Results

In this study the data collection efficiency of the adopted air quality monitoring stations is generally higher than 80.0% in 2014. This satisfies the minimum percentage of 75.0% according to the code of practice. Table 1 shows the number of stations exceeding the China air quality standard (SO_2, PM_{10}, $PM_{2.5}$, NO_2, CO and O_3) for each city and the corresponding number of exceedances for the annual/daily/hourly standards in 2014. SO_2 and CO have the fewest exceedances compared to the other pollutants. All the stations complied with the annual limit value for PM_{10} (annual limit value for PM_{10} is 70 $\mu g.m^{-3}$) and there are 0-22 (0-6.0%) exceedances of the daily limit value for this pollutant (daily limit value for PM_{10} is 150 $\mu g.m^{-3}$). None of the stations complied with the annual limit value for $PM_{2.5}$. The average annual concentration is 21.0-25.7% higher than the limit values of $PM_{2.5}$ (annual limit value for $PM_{2.5}$ is 35 $\mu g.m^{-3}$). In addition, there are 1-60 (0.3-16.4%) exceedances of daily limits for this pollutant. As for NO_2, it has widespread violation of the annual/daily/hourly threshold values over the entire PRD. Between 3 and 8 stations did not complied with the annual limit value for NO_2 in the northern PRD (annual limit value for NO_2 is 60 $\mu g.m^{-3}$). The air quality monitoring stations have 0-238 (0-65.2%) exceedances of daily limits for NO_2 (daily limit value for NO_2 is 80 $\mu g.m^{-3}$). Finally, this pollutant recorded 0-386 exceedances of hourly limit (hourly limit value for NO_2 is 200 $\mu g.m^{-3}$). Ozone recorded 0-32 and 0-264 exceedances of the daily maximum of the 8-hour averaged limit as well as the hourly limit, respectively (daily maximum of 8-hour average and hourly limit value are 160 and 200 $\mu g.m^{-3}$, respectively). In the three major cities of Guangdong and Macau the highest concentrations of almost all pollutants shown in Table 1 were generally registered to north and northeast winds. Depending on the location of the air quality monitoring station, the wind directions associated with the highest concentrations of Hong Kong could be northeast, east and southeast. This is due to the complex topography of Hong Kong (Fung, 2005). Except ozone which is formed through the photochemical reactions, the highest concentrations of the other pollutants in all cities were recorded in winter (November and

February). This may be due to the smaller mixing height, lower amount and frequency of rainfall during that period (Mok and Hoi, 2005).

Table 1: Exceedances of China ambient air quality standard across main cities of PRD in 2014.

		Guangzhou	Dongguan	Foshan	Macau	Hong Kong
Pollutant	Sampling frequency	Exceedances number				
SO_2	Annual	No exceedances (16.7 μg.m^{-3})	No exceedances (21.2 μg.m^{-3})	No exceedances (25.2 μg.m^{-3})	-[*1]	-[*1]
	Daily	0-1	0	0	0	0
	Hourly	0	2-24	0	0	0
PM_{10}	Annual	No exceedances (60.5 μg.m^{-3})	No exceedances (55.1 μg.m^{-3})	No exceedances (59.7 μg.m^{-3})	-[*1]	-[*1]
	Daily	1-13	0-6	4-22	2-7	0-1
$PM_{2.5}$	Annual	All stations (47.1 μg.m^{-3})	All stations (44.3 μg.m^{-3})	All stations (43.3 μg.m^{-3})	-[*1]	-[*1]
	Daily	28-59	25-35	19-60	12-39	1-12
NO_2	Annual	8 stations (45.2 μg.m^{-3})	3 stations (42.0 μg.m^{-3})	6 stations (46.6 μg.m^{-3})	-[*2]	-[*1]
	Daily	0-69	7-15	13-64	-[*2]	19-238
	Hourly	0-24	3-10	0-40		0-386
CO	Daily	0	0	0	-[*2]	0
	Hourly	0	0-2	0		0
O_3	Daily, 8-hour Maximum	2-32	11-21	5-16	2-11	0-12
	Hourly	44-201	139-264	48-141	17-77	0-56

-[*1] Data was incomplete for 2014; -[*2] No data for this pollutant

Here, the $PM_{2.5}$, which is the dominant pollutant of PRD during the study period, was adopted for demonstration. Figure 2 shows the 24-hour backward trajectories of air masses tracking from Huadu station. This station was selected since the highest annual concentration and number of exceedance were recorded here. For a given month in winter, spring or summer, two dates with the highest or lowest $PM_{2.5}$ concentrations were selected for analysis.

In winter and spring, the highest $PM_{2.5}$ concentrations observed at the Huadu station were mainly associated with air masses crossing the cities situated at the China-Taiwan strait region with high population densities. The lowest $PM_{2.5}$ concentrations were associated with the trajectories from north which cross the region with relatively lower population. As for summer this station was affected by air masses from the South China Sea. Although the trajectories causing high/low concentrations are similar in summer, it should be noted that there is distinct seasonal behaviour of $PM_{2.5}$ in PRD. Therefore, the highest $PM_{2.5}$ level during the summer month should be lower than the one observed in winter.

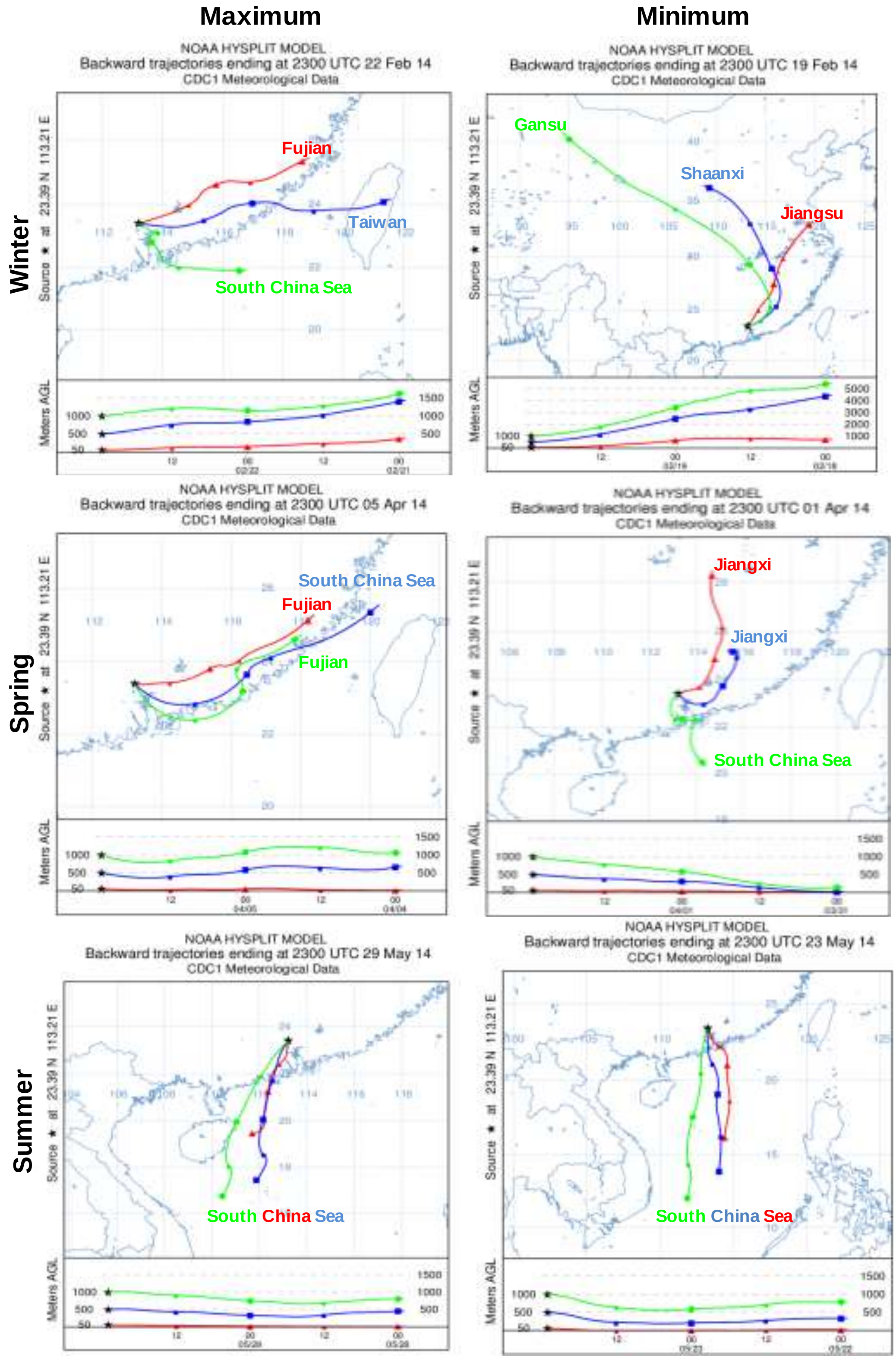

Figure 2: Backward trajectories of air masses for Huadu station in three seasons (Produced using NOAA ARL Website: www.arl.noaa.gov)

4. Conclusions

In 2014 PRD recorded severe exceedances of the China air quality standards (GB 3095-2012) especially for $PM_{2.5}$. It was concluded that $PM_{2.5}$ is the dominant pollutant in this region. Furthermore, the highest concentrations were generally observed in winter and were associated with the northeast air mass trajectories crossing the China-Taiwan strait with high population densities. Therefore, the PRD region may be also affected by the transboundary pollution besides its own emissions.

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