Atmos. Chem. Phys. Discuss., 13, C3776–C3785, 2013
www.atmos-chem-phys-discuss.net/13/C3776/2013/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Study on the atmospheric boundary layer and its influence on regional air quality over the Pearl River delta" *by* M. Wu et al.

M. Wu et al.

wumeng@mail2.sysu.edu.cn

Received and published: 16 June 2013

We would like to thank Referee 1 for your careful reading of our manuscript and for your valuable and constructive comments. We have addressed the comments below.

Comment:

This manuscript presents "the atmospheric boundary layer and its influence on regional air quality over the Pearl River Delta". The authors discuss the situations of atmospheric conditions which related to the high pollution episodes. Most of the results relied on the radio sounding and the index they deduced. However, the authors

fail to present some important concepts of physical processes. They totally confused the land-sea breeze processes with the prevailing wind and did not clearly identify so called" heat island circulation". For example, they presented "sea breeze" developing from 17:00 to 23:00 LST (page 10, line10-22). Another example shown in Page 12, line1: "At 23:00 LST, the wind speed reached maximum since the influence of sea breeze was most remarkable"

As we know the "sea breeze" is formed by increasing temperature differences between the land and sea during daytime. It is inappropriate to suppose all of the onshore flow as sea breeze. It could be prevailing wind. Also, the evidences are still too rough to define the "heat island circulation" just only from the radio sounding.

Response:

The special geographical conditions of Pearl River Delta (PRD) have significant impacts on the regional flow and air quality (Fan, 2005). From the data analysis of PRIDE-PRD 2004 and PRIDE-PRD 2006, respectively, it was found that the high-level concentrations of air pollutants usually occur in autumn and winter over PRD, the surface high-pressure system (anti-cyclone), descent motion outside of hurricane and sea breeze would result in the high-level concentrations (Fan et al.2008, Fan et al.2011).

In this paper, we comprehensive analysis of the atmospheric boundary layer(ABL) data from PRIDE-PRD 2004 and PRIDE-PRD 2006, especially want to explore the detail atmospheric conditions with high pollution episodes over PRD.

We agree that it is very important to distinguish sea breeze and onshore flow in analysis. Not all of the onshore flow is sea breeze. Sea breeze only appeared in some place which fulfilled the certain land-sea thermal difference. At low latitudes as PRD, previous observations had proved that the sea breeze emerged relatively late, and lasted for longer timeïijĹLi,2007ïijL'. In this paper, we used the temperature difference between Xinken (near the coast) and Panyu (off the coast, urban site) and wind direction, wind speed change to identify sea-land breeze, the temperature difference had

been showed in Fig.8. For example, in Fig.8a, the temperature difference was quite remarkable, and then the day was a typical sea-land breeze day.

Heat-island circulation is a very important factor on air quality of PRD (Wang et al., 2004;Wu et al., 1986). In this paper, we only have done a qualitatively study and found some performance of heat island circulation from Panyu (urban site) observation data with theoretical assumption. The updraft was inferred from the theory of heat-island circulation and limited observation data of Panyu. We will do another special observation campaign for heat-island circulation over PRD, the detail analyze of heat-island circulation may be given in future, but not in this paper.

We have revise and improve these statements in revision paper.

Comment:

1. Overall, this paper discussed the well known situations of atmospheric conditions which related to the high pollution episodes. Thus, the data quality and the methods are quite critical for this paper to be published. What's new in this study comparing to previous investigations (Fan et al.2008, Fan et al.2011)? They all studied the cases in 2004 and 2006.

Response:

Fan et al. 2008 studied on the meteorological conditions and structures of ABL over PRD by using the observation data of October 2004, which had focused mainly on the averaged conditions, such as variations of wind direction, flow patterns, averaged wind profiles and averaged temperature profiles. Fan et al. 2011 studied on the characteristics of ABL in July 2006 by measurements and simulations, they based on the WRF model revealed that the simulated temperature and wind fields in three cases (subsidence days, rainy days, and sunny days) were moderately consistent with the measurements, and used little measurements data, especially Xinken's data didn't been used.

In this paper, we comprehensively analyzed all the measurements data of 2004 and 2006, and focused on the influence of boundary layer meteorology (BLM) on regional air quality. We found the typical weather condition type associated with poor air quality over PRD could be summarized into two kinds: the warmed period before cold front (WPBCF) and the subsidence period controlled by tropical cyclone (SPCTC). In addition to the traditional analysis method, we introduce three new BLM analysis tools as balloon trajectory distribution(BTD), Recirculation factor (RF) and Ventilation index(VI) to detail analysis two typical polluted cases (affected by WPBCF and SPCTC, respectively) and one clean case (not-polluted). It were found that BTD, RF, VI were quite different between polluted cases and the clean case. RF and VI are good reference index for pollution judgment. Summarize the typical structure of BLM causing high air pollution over PRD in different weather conditions as Fig.9. That is the main new in this study comparing to previous investigations.

Comment :

2. Abstract: line 20"The peak mixing heights were smaller than 700m in WPBCF cases, and were smaller than 800m in SPCTC cases." Why you emphasis this point? For me, this difference is not significant.

Response:

This is our representation unclear. Yes, the peak mixing heights difference between these two polluted cases is not significant, but the peak mixing heights difference between polluted cases and clean case is significant. The peak mixing heights in clean case is about 1250m, but in polluted cases was lower than 800m(WPBCF cases about 700m , SPCTC cases about 800m), see table.3. We have corrected this error in revision paper.

Comment:

3. P9 "Figure 3 gives the surface wind fields from the main meteorological stations to

provide overviews about the features of air flowing conditions in these three cases." How do you plot this figure? It seems to me the data are not from meteorological stations. I do not believe you have so density meteorological stations.

Response:

This is our representation unclear.

There are only nine meteorological stations in PRD, but has many automatic weather stations in PRD. Figure 3 was plotted by interpolated data from 27 automatic weather stations of PRD. We have added some sentences to state the source of data in revision paper.

Comment:

4. P10.Lin10-28: Section 4.2 as pointed in general comment, this section has seriously concept problem about the description of land-sea breeze processes.

Response:

Sea-land breeze circulation was driven by the thermal contrast between the ocean and the land of coastal zone, which results in the confluence of air originating over the ocean with air originating over the land. The sea-land breeze is associated with many processes that contribute to the recirculation and trapping of pollution, the moisture and aerosol gradients, the formation and transport of fog and low cloud in the coastal zone.

Qualitative description of a sea-breeze mechanism is: In a calm atmosphere during a clear day, the surface of the land is heated by solar radiation and becomes warmer than the sea surface. As warmed air rises over the land a local circulation current begins, drawing cool air in from the sea. The ascending air returns seaward in the upper return current, increasing the momentum of the cycle and spreading the effect over a greater area of land. If general wind circulation in an area is weak, a sea-breeze will usually commence soon after the temperature of the land exceeds that of the sea. The sea-

breeze will increase in strength and reach farther inland as the temperature difference increases. A moderate to strong prevailing offshore wind will delay or prevent the development of a sea-breeze. On the other hand, a light to moderate prevailing offshore wind will reinforce a developing sea-breeze. Sea-land breeze circulation is affected by coastline shape, geographical features, time, and prevailing weather patterns, etc. A sea-breeze can be identified by a lower temperature and higher humidity than the existing wind.

In this paper, we use the sunny day radio sounding temperature and wind profiles at Xinken and Panyu to identify sea-land breeze. The temperature profiles had been showed in Fig.8. We have added some sentences to state the Sea-land breeze circulation in revision paper.

Comment:

5. Figure 4, what is the unit of x-coordinate and y-coordinate in Figure 4b and c

Response:

This is our representation unclear.

We used Figure 4b and c to show the horizontal projection trajectory of balloons release at Xinken and Panyu, so only plotted direction N and E. We have added x-coordinate and y-coordinate in revision paper.

Comment:

6. Figure 4: For me, the radio sounding already traveled away from the launch locations, Xinken and Panyu (from figure 4b and c). It is inadequate to explain the wind data as right up of these stations.

Response:

Yes, the radio sounding balloon would travel away from the launch location, this is a common problem during the studies of the vertical wind profile based on balloon

observation. It is inadequate to explain the wind data as right up of the station, but the balloon trajectory is believable evidence. Balloon observation is still considered to be one of the effective methods for BLM observation.

In this paper, we calculate different positions' wind direction, wind speed from the balloon moving trajectory (Figure 4c and d), neglected the travelling distance and regarded the soundings profiles as right up of the station (Figure 4a and b), with these two kinds dada analysis to qualitative description the main features of vertical wind.

Comment:

7. P11, line1-5, the wind speed is quite weak, it does not make sense to discuss the wind direction change.

Response:

In general, the wind direction will change very fast when wind speed is quite weak, so discuss the wind direction change when wind direction change very fast does not make sense.

But in this cases, the weak wind speed is due the country breeze direction was opposite to system wind direction, so it is necessary to discuss the wind direction change with height to see the effected by heat island circulation. We found that the direction of country breeze was opposite to system wind at low level, but veered to the same direction at middle level, the wind direction was northeast till 14:00 LST. After 17:00 LST, the wind speed was low at both middle and high level, while wind direction turned to the same direction as northwest.

Comment:

8. P12 line1: "At 23:00 LST, the wind speed reached maximum since the influence of sea breeze was most remarkable." "At 23:00 LST, the influence of sea breeze was most remarkable", I do not believe.

Response:

This is a mistake. Thank you to point out.

The corrected statement should be "At 20:00 LST, the wind speed reached maximum since the influence of sea breeze was most remarkable." We have corrected this mistake in revision paper.

At low latitudes as PRD, the sea breeze emerged relatively late, and lasted for longer time. In the campaigns of 2004 and 2006, it is found that sea breeze started at about 17:00 and reached maximum at about 20:00 (Zhuang et al., 2011; Zhang et al., 2009; Li et al, 2007). Our result "At 20:00 LST, the influence of sea breeze was most remarkable" was consistent with the result of previous study.

Comment:

9. Page 13 Line 1: How do you clearly identify the updraft is only influence from so called "heat-island circulation", You do not have any data to show how strong the urban heat island effect is.

Response:

Heat-island circulation is a very important factor on air quality of PRD (Wang et al., 2004;Wu et al., 1986). In this paper, we only have done a qualitatively study and found some performance of heat island circulation from Panyu (urban site) observation data with theoretical assumption. The updraft was inferred from the theory of heat-island circulation and limited observation data of Panyu.

We will do another special observation campaign for heat-island circulation over PRD, the detail analyze of heat-island circulation may be given in future, but not in this paper.

We have added some sentences to state these in revision paper.

Comment:

10. P14: line 10-20: The same question as pointed out in general comment.

Response

We have answered in general comment, and we also have revised and improved these statements in revision paper.

References:

1. Fan S. J., et al., Atmospheric boundary layer characteristics over the Pearl River Delta, China, during the summer of 2006: measurement and model results, Atmos. Chem. Phys., 2011, 11(13), 6297–6310

2. Fan S. J., et al., Meteorological conditions and structures of atmospheric boundary layer in October 2004 over Pearl River Delta area, Atmospheric Environment, 2008, 42(25), 6174-6186

3. Fan S. J. 2005. Study on the characteristics and effect of urbanization on the atmospheric boundary layer over the Pearl River Delta (in Chinese). Ph.D. paper in Sun Yat-sen University, 34–57.

4. Li M. H., et al., Sea-land Breeze on the West Coast of the Pearl River Mouth in October 2004 (in Chinese). Acta Scientiarum Naturalium Universitatis Sunyatseni, 2007, 46(2): 123-125

5. Wang X. M., et al., Surface Ozone Concentration in Guangzhou under Different Meteorological Conditions (in Chinese), Journal of Tropical Meteorology, 2004, 20(5): 571-578

6. Wang X. M., Simulation of Local Circulation in Guangzhou District (in Chinese), Plateau Meteorology, 2003, 22(2), 197-201

7. Wu Y. B., Heat Island Character and Its Influence on Air Pollution over Guangzhou (in Chinese), Journal of Tropical Meteorology, 1986, 2(3): 242-250

8. Zhang L. F., et al., Study of Sea- Land Breeze System in the Mouth Area of the Zhujiang River (in Chinese). Chinese Journal of Atmospheric Sciences, 1999, 23(5): 581-589

9. Zhuang Y. J., et al., Preliminary research on the carbonyl compounds under of sea-land breeze at the west coast of the Pearl River Estuary (in Chinese). China Environmental Science, 2011,31(4)ïijŽ568-575

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 6035, 2013.