Atmos. Chem. Phys. Discuss., 11, C13638–C13642, 2011
www.atmos-chem-phys-discuss.net/11/C13638/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Spatial-temporal variations of surface ozone and ozone control strategy for Northern China" *by* G. Tang et al.

G. Tang et al.

tgq@dq.cern.ac.cn

Received and published: 28 December 2011

We would like to thank anonymous referee for his/her comments and helpful suggestions. We revised our paper according to these comments and suggestions.

Major comments:

Question 1: Section 3.4.2, pg 26075, lines 5-14: The WRF-simulated dry deposition velocity shows a 22% increase from June to July over North China. The authors argue this reduction contributes to the observed ozone decrease from Jun to July. To make the argument more convincing and scientific interesting, the authors need to (1) quantify the change in dry deposition flux (rather than dry deposition velocity) between the two months and (2) discuss the factors that drive the increase in dry deposition.

Response: We accepted your suggestions. The Vd is computed in MCIP based on Wesely method (Wesely, et al., 1989). Vd=1/(Ra+Rb+Rc) (1) Where Ra is the aerodynamic resistance, Rb is the quasi-laminar boundary layer resistance, and Rc is the canopy resistance. Among three resistances, Rc is the highest one for ozone (Pan, 2009), so seasonality of Vd is dominated by variation of Rc. In addition, solar radiation and leaf area index (LAI) are two main factors for Rc. The dominated landuse over northern China is crop and Vd of ozone over crop is not sensitive to solar radiation (Pan, 2009). Therefore, Vd of ozone is a function of LAI. Considering the higher leaf area index in July in Northern hemisphere (van den Hurk, et al., 2003), the WRF-simulated dry deposition velocity shows a 22% increase from June to July over North China.

In order to quantify the changes of dry deposition flux, we calculate them using the following equation. F=-Vd$\times$C (2) Where F is the ozone dry deposition, C is the observed concentrations for ozone and Vd is the ozone dry deposition velocity computed by MCIP. In the context, ozone concentrations are highest in June. However, considering the lower ozone dry deposition velocity compared to July, the dry deposition flux still exhibit a 13.5% increase from June to July.

Question 2: Section 4.2, pg 26079-26080: the authors find that the spatial distribution of meteorological parameters corresponds well with the spatial distribution of ozone exceedances, thus arguing the domination of meteorological processes on ozone production over emissions. As no one expects to see homogenous meteorological patterns over North China, are the spatial differences in temperature, RH, radiation, and cloud fraction shown in Figure 14 really statistically significant? The color scale in Fig 14 makes them appear to look different, but statistical analysis is warrant.

Response: Thanks for your suggestions. We extracted 22 sites (same to air quality stations) meteorological data from WRF, and added the statistically results to make this section more clearly.

Question3: It seems that the monitoring sites also have VOCs measurements as indicated in the abstract and introduction. Why do the authors choose to use satellite observed HCHO/NO2 column ratios, rather than using concurrently measured VOCs and NOx ratios, to infer the sensitivity regime of ozone chemistry? The measured ratio should at least provide consistency checks on the regime analysis.

Response: In this project, the measurement of VOCs is the responsibility of Peking University, not our institute. In addition, the VOCs data is monitored one time per season. In other words, the time resolution is just one hour per season. Therefore, it is not suitable for our analysis because of the low time resolution. According to the two reasons above, we used space-based HCHO and NO2 to analyzing the ozone-NOx-VOCs sensitivity instead of ground-based measurements. We also considered comparing the measurements with satellite data. However, it is difficult to compare monthly satellite data with hourly measurements. In spite of these reasons, it still deserves us to use VOCs data in the future analysis. Therefore, we prepare to do some modeling work to compare the VOCs measurements with simulations, and also to compare the satellite results with modeling results.

Question4: The paper has a lot of figures. I suggest removal of a couple of figures that are not critical for the analysis or put them in a supplemental material, e.g., Figure 2 (the WRF domain) and Figure 4. The wind vectors in Figure 4 are hard to see. With Figure 3 already showing the seasonal variation of meteorological parameters, Figure 4 is redundant.

Response: We accept the suggestions and moved Fig. 2 to the supplemental material. As to Fig. 4, we will adjust the wind vectors for readers. However, I think it is essential in this paper, because it showed the prevailing winds and PBLH in different seasons which are two important factors for our analysis.

Minor comments:

Question 1: pg 26067, equation 3: define DO3(t) in the equation.

Response: We accepted the suggestion and added the definition in the manuscript as follow. DO3(t) represents the concentration at time t corresponding to the cumulative mass of ozone lost from time zero to t.

Question 2: pg 26075, line 5: Figure 6 should be Figure 9.

Response: We accepted the suggestion and revised it in the manuscript.

Question 3: pg 26078, line 16-19: How do the authors calculate the photochemical production rate of ozone per day? Can the authors calculate the dry deposition loss of ozone per day? The comparison of the dry deposition loss rate (ppbv/day) in June and July can offer a more direction evidence for the importance of dry deposition in causing the observed June to July ozone reduction.

Response: We calculated the photochemical production rate of ozone per day using the difference of daily maximum and minimum Ox. Although this method removes the influence of the reaction of NO and ozone, the daily ranges are still stand for the total amount of ozone production and loss. Therefore, this is a roughly estimation for ozone production. Such as it is, this method is widely used in some papers (Zhang et al., 2008; Tang et al, 2009) because its effectiveness and simplicity.

We accepted your suggestions and will added the results of ozone deposition flux to discuss the reasons of June ozone peak. Please see detailed description in major comments question 1. However, ozone loss rates are calculated using the equation (2). Because ozone dry deposition flux represent the column loss rates, the unit of ozone loss rate is μgâĂćm3âĂćs-1.

Question 4: Figure 9 caption: 9b should be dry deposition velocity of ozone.

Response: We accepted the suggestion and revised it in the manuscript.

Question 5: In abstract, line 5-6: the text on PM10, PM2.5, and VOCs should be removed from the abstract because these measurements are not shown in the paper.

Response: We accepted the suggestion and revised it in the manuscript.

Question 3: pg 26060, line 8: surround should be surrounding; pg 26061, line 3: lead should be lead to; pg 26073, line 15: resulted should be result

Response: We accepted the suggestion and revised it in the manuscript.

References:

Pan, X.: Observation and modeling studies on the dry deposition of major air pollutants in North China, Ph.D thesis, 157pp., 2009.

Tang, G., Li, X., Wang, Y., Xin, J., and Ren, X.: Surface ozone trend details and interpretations in Beijing, 2001–2006, Atmos. Chem. Phys., 9, 8813–8823, doi:10.5194/acp-9-8813-2009, 2009.

van den Hurk, B. J. J. M., P. Viterbo, and S. O. Los (2003), Impact of leaf area index seasonality on the annual land surface evaporation in a global circulation model, J. Geophys. Res., 108(D6), 4191, doi:10.1029/2002JD002846.

Wesely, M. Parameterization of surface resistances to gaseous dry deposition in regionalscale numerical models. Atmospheric Environment (1967), 1989, 23(6): 1293-1304.

Zhang, Y. H., Su, H., Zhong, L. J., Cheng, Y. F., Zeng, L. M., Wang, X. S., Xiang, Y. R., Wang, J. L., Gao, D. F., Shao, M., Fan, S. J., and Liu S. C.: Regional ozone pollution and observation-based approach for analyzing ozone-precursor relationship during the PRIDE-PRD2004 campaign, Atmos. Environ., 42, 6203–6218, 2008.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 26057, 2011.