Atmos. Chem. Phys. Discuss., 13, C6150–C6157, 2013
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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "NO_x emissions in China: historical trends and future perspectives" *by* B. Zhao et al.

B. Zhao et al.

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General Comments:

NOx emissions in China not only affect the local and regional air quality of China, but also pose multiple adverse impacts on the human health, ecosystem and climate forcing in the East Asia and the hemisphere via large-scale tropospheric ozone and PM pollution, which have aroused great concerns throughout the whole world. Thus, it is of great significance to know well about the historical trends, present status and future changes of NOx emissions in China. Particularly, it is very important to demonstrate the future scenario for NOx reduction based on the scientific knowledge about emission structure and various emission control measures. The study conducted by Zhao

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and coauthors provides a historical emission inventory for NOx during 1995-2010 using a consistent model structure and detailed Chinese data sources for activity data and emission parameters; and also the future trends up to 2030 are forecasted by applying scenarios analysis. In particular, within the reviewer's knowledge this article is the first study in which the NOx emissions in China are estimated during 1995-2030 using aconsistent methodology and are predicted based on the various emission scenarios on accounting of end-of-pipe control measures as well as energy-saving measures. The author's efforts have made new NOx emission inventory study more reliable and complete compared to others previously reported, which will be a good reference for polymaking of NOx reduction in China. Consequently, this reviewer believes that the paperis of the interest of Atmospheric Chemistry and Physics and recommends publishing this paper with minor revisions in response to the following questions, comments, and suggestions.

Response: We thank the reviewer for supporting the publication of our manuscript. We also appreciate his/her comments which help us improve the quality of our manuscript. We address the reviewer's comments below. The responses are provided just following the reviewer's comments.

Specific questions and comments:

1. Page 16052, Line 10: The "specific control technology" is "specific air pollutants control technology"?

Response: The "specific control technology" is "specific air pollutant control technology". We have revised it in the manuscript to avoid confusion. (Page 5, Line 6-7 in the revised manuscript; please find the revised manuscript in the supplement.)

2. Page 16053, Lines 22-30: The soil NOx is an important emission source in China.Why the authors don't include the soil NOx?

Response: We thank the reviewer for this comment. We agree with the reviewer that the soil NOx is an important emission source in China. However, this manuscript focuses on the historical trends of anthropogenic NOx emissions, and the impact of potential energy saving policies and pollution control policies on future trends of NOx emissions. Considering the difficulties to control soil emissions, we did not include soil NOx emissions but rather focused on the energy related NOx emissions. We have added the explanations accordingly in the manuscript. (Page 6, Line 19-22 in the revised manuscript)

3. Page 16061, Lines 21-22: The authors should cite the relevant references for this assumption.

Response: We thank the reviewer for this comment. In the revised manuscript, we have provided more detailed explanation for this assumption, and cited relevant references accordingly (see Page 12, Line 28 to Page 13, Line 7 in the revised manuscript).

Since 1997, the government enacted a series of regulations and laws to prohibit field burning (Yan et al., 2006). A formal regulation to prohibit field burning and promote environmental friendly utilization of agricultural residues was published in 1999 (State Environmental Protection Administration, 1999). Farmers are encouraged to return crop residue to agricultural soils as fertilizer. In addition, China's Ministry of Environmental Protection (MEP) released a notice to strengthen the prohibition of open burning before the harvest season almost every year (http://www.zhb.gov.cn/). Moreover, since 2004, MEP has been monitoring agricultural field burning with satellites, and a report of the numbers and locations of fire points has been published every day (http://hjj.mep.gov.cn/stjc/). Once the field burning was confirmed by satellite observations, local officials would take quick actions to forbidden such behavior. Considering the government's continuous efforts to prohibit open burning, we assume the crop residue burned in the field will decline by 10% every five years in both BAU and PC scenarios.

References:

State Environmental Protection Administration: Administrative regulations to prohibit field burning and promote environmental friendly utilization of agricultural residues, http://www.mep.gov.cn/gkml/zj/wj/200910/t20091022_171920.htm, last access: 5 May 2012, 1999 (in Chinese).

Yan, X. Y., Ohara, T., and Akimoto, H.: Bottom-up estimate of biomass burning in mainland China, Atmos. Environ., 40, 5262-5273, doi: 10.1016/j.atmosenv.2006.04.040, 2006.

4. Page 16073, Lines 9-11: The reason why the CV varies with emission sector should be discussed. Especially, why is the CV of emissions from transportation higher?

Response: We thank the reviewer for this comment. The variation of CVs with emission sectors is attributed to different magnitude of uncertainties associated with activity levels and emission factors. Biomass open burning has the largest CV because both the activity level and the emission factors are quite uncertain. The CV of transportation sector is larger than power and industrial sources (though smaller than that of biomass open burning), as the fuel consumption of on-road vehicles is calculated from vehicle population, annual average vehicle mileage traveled, and fuel economy, rather than the energy statistics (see Sect. 2.1.1). We have added the explanation accordingly in the revised manuscript (Page 22, Line 31 to Page 23, Line 4 in the revised manuscript).

5. Page 16076, Line 25: What is the “standard” scenario?

Response: We appreciate the reviewer’s comment, and we are sorry for the confusing description. We have revised this sentence as follows:

It is instructive to quantify the impacts of some key factors on the future emissions, which were not considered in the scenarios developed in this study (see Table 1). (Page 25, Line 31 to Page 26, Line 2 in the revised manuscript)

Similar descriptions in the following paragraphs have also been revised accordingly.

6. Section 3.4: The spatial distribution of large point sources and spatial proxies will

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vary during 2010-2030 depending on the scenario. The spatial distribution within a specific province is fixed? It is suggested that the authors explain the temporal changes of spatial proxies.

Response: We appreciate the reviewer's comments. We have explained the temporal changes of the geographical locations of large point sources and spatial proxies in the revised manuscript:

Most coal-fired power plants, iron and steel plants, and cement plants were identified as large point sources, and allocated based on their geographical coordinates. The historical geographical locations of these large point sources were updated year-by-year based on the annual reports of industrial associations. As for future development, we first calculated provincial emissions based on the assumed energy saving policies and emission control policies. The locations of large point sources within a specific province were assumed to remain the same as 2010, and the NOx emission of each point was calculated based on the growth rates of provincial emissions. The other sources were treated as area sources, the emissions of which were distributed into 36 kmïĆť36 km grid cells using various spatial proxies at a grid resolution of 1 km * 1 km using the methodology described in Streets et al. (2003) and Woo et al. (2003). These spatial proxies are assumed to remain unchanged from 2010 afterwards. (Page 27, Line 18-29 in the revised manuscript)

References:

Streets, D. G., Bond, T. C., Carmichael, G. R., Fernandes, S. D., Fu, Q., He, D., Klimont, Z., Nelson, S. M., Tsai, N. Y., Wang, M. Q., Woo, J. H., and Yarber, K. F.: An inventory of gaseous and primary aerosol emissions in Asia in the year 2000, J. Geophys. Res-Atmos., 108, doi: 10.1029/2002jd003093, 2003.

Woo, J. H., Baek, J. M., Kim, J. W., Carmichael, G. R., Thongboonchoo, N., Kim, S. T., and An, J. H.: Development of a multi-resolution emission inventory and its impact on sulfur distribution for Northeast Asia, Water. Air. Soil. Poll., 148, 259-278, 2003.

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7. Section 3.5: For verification of the historical trend of NOx emissions, the satellite NO2 vertical column density (VCD) is very useful. I suggest that the authors compare with recent trends by satellite NO2 VCD and make some discussion about it.

Response: We thank the reviewer for this valuable comment. In the revised manuscript, we have compared the relative changes of satellite NO2 vertical column density (VCD) with those of the anthropogenic NOx emissions (see Figure 1 below, or Figure 12 in the revised manuscript). Zhang et al. (2012) retrieved and analyzed the satellite NO2 VCD during 1996-2010, in which measurements of Global Ozone Monitoring Experiment (GOME) from April 1996 to the end of 2002, and the measurements of Scanning Imaging Absorption Spectrometer forAtmospheric Cartography (SCIAMACHY) from 2003 to 2010 were used. In this study, we adopted the satellite NO2 VCD derived by Zhang et al. (2012). We compared the changes of NOx emissions and the satellite NO2 VCD in East Central China (ECC,110°–123°E, and 30°–40°N). The bottom-up emission estimate indicates a 124% increase of the anthropogenic NOx emissions in ECC during 1996–2010, slightly lower than the 184% increase in the NO2 VCD. The difference between the two growth rates is acceptable, considering the uncertainties in emission estimates and satellite retrievals, and the inter-annual variations of the meteorological factors. In terms of five-year intervals, the growth rates based on bottom-up emission estimates are 7%, 60%, and 31% during 1996-2000, 2000-2005, and 2005-2010 respectively. The satellite observations indicate the corresponding growth rates are 17%, 82%, and 34%, respectively.

We have added the descriptions above as well as Figure 1 in the revised manuscript. (Page 29, Line 18-32 in the revised manuscript)

Reference:

Zhang, Q., Geng, G. N., Wang, S. W., Richter, A., and He, K. B.: Satellite remote sensing of changes in NOX emissions over China during 1996-2010, Chinese. Sci. Bull., 57, 2857-2864, DOI 10.1007/s11434-012-5015-4, 2012.

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8. Table 6: The removal rate of a specific air pollutants control technology (parameter "d" in Eq. (3)) used in this study should be shown in Table 6 or other.

Response: We thank the reviewer for this comment. We have added the removal rates of air pollutant control technologies in Table 6.

9. Fig.10: The legend is invisible and should be improved.

Response: The resolution of the legend has been improved in the revised manuscript.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/13/C6150/2013/acpd-13-C6150-2013-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 13, 16047, 2013.

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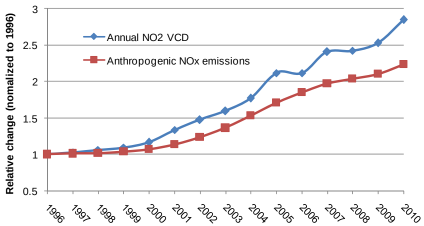

Figure 1 Inter-annual relative changes in the NO_2 VCD and anthropogenic NO_X emissions. All data are normalized to the year 1996. Study region: 30°–40°N, and 110°–123°E. (Figure 12 in the revised manuscript)

Fig. 1.

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