Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-601-AC1, 2017

Atmospheric Chemistry and Physics
Discussions
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Interactive comment on "Impacts of Coal Burning on Ambient $PM_{2.5}$ Pollution in China" *by* Qiao Ma et al.

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Received and published: 12 January 2017

1. Emission inventory: do the authors estimate CO emissions as well or they were obtained from other studies?

Response: In this study, we didn't develop emission inventory for CO. The CO emission we used in this study is from EDGAR v3 in global simulations, which is overwritten by INTEX-B (http://mic.greenresource.cn/intex-b2006) in the nested domain of East Aisa.

2. The model evaluation. The authors used NMB as an indicator, which could potentially be affected by the compensation of overestimation and underestimation of CTM. I suggest them provide NME for Figs 3 and 4.

Response: As suggested, we calculated the NME for Fig. 3 and 4 in manuscript. For

Fig. 3, the NME of simulated PM2.5 concentrations in NEC, NC and YRD regions are estimated to be 38%, 45% and 36%, which is the same as the value of NMB, as the model underestimated the PM2.5 concentration throughout the year. In MYR, SCB and PRD regions, the NME are estimated to be 18%, 21%, 22%, which are higher than the estimated NMB, especially in SCB. Overall, the model can reproduce the monthly variation of ambient PM2.5 concentration in these key regions. For Fig. 4 in manuscript, the NME of sulfate, nitrate, ammonium, BC and OC are estimated to be 58%, 41%, 28%, 44% and 50%. The NME of nitrate and ammonia show large difference with NMB. The difference mainly arise from the discrepancies between simulation and observation in NC and MYR. In addition, we add the comparison of simulated PM2.5 composition with observation data averaged during 2012-2013 (X. Zhang et al., 2015), which is shown in Fig. 1 in this reply. The information of each site is described in detail in Zhang et al. (2012). The sulfate is underestimated by 40.5%, which mainly occurs in the two cities of Zhengzhou and Xi'an, two orange spots in central and north China, as these two sites are located in urban area. Nitrate and ammonia are overestimated by around 20%, which is a common issue in most CTMs. OC is underestimated by 28.9% due to the incomplete mechanism of SOA simulation. The NME is calculated between 30% and 41%. Generally the model can reproduced the special distribution of PM2.5 speciation. We add the text and figures in the manuscript as suggested.

3. More discussions should be given in uncertainty analysis. For example, the authors discussed the uncertainty of emission estimations based on Monte-Carlo simulation. However, it was not sufficient for readers to know the impacts of emission inventory estimation on the source apportionment results. More comparisons between various inventory studies are encouraged here to indicate the potential uncertainty of source apportionment from emission side. Moreover, there are some studies using the methods other than Brute-force to reduce the impacts of non-linear response of PM2.5 concentrations to precursor emissions, and they should be included in the part.

Response: We looked into recent studies on major pollutant emissions in China and summarized them in Table 1 in this reply. Emissions from Liu et al. (2016), Xia et al. (2016) and Wu et al. (2016) are also estimated using bottom-up method, while those from Zhao et al. (2014) are projected emissions for 2015 based on the year of 2010. We can see that the results of this study fall into the range of previous studies except for MEP (2014) which is at low end. One major reason for low NOx emission from MEP(2014) is that it does not include the emissions from non-road vehicles.

Regarding to the non-linearity of atmospheric chemistry, there are some studies using different methods to study the source apportionment of ambient PM2.5. As this study only focuses on coal-burning emissions in each sector, the results are not directly comparable to most similar studies except for results for power sector, as coal combustion dominates the emissions in power plants. Zhao et al. (2015) used the extended response surface modeling (ERSM) technique to access the non-linear response of fine particles to precursor emissions in each sector in PRD region, reporting that local PM2.5 concentration decreased less than 3% (7.2% in our study) in January and around 12% in august (13.8% in our study) when 90% of emissions in power plants are reduced. Our results include the trans-boundary contributions as we shut off emissions across the country in the sensitivity simulation, which is one of the reasons causing the discrepancies. L. Zhang et al. (2015) took the advantage of the adjoint capability of GEOS-Chem, reporting that power plants contributed 6% to PM2.5 concentration in Beijing, which is consistent with our study (6.9%). We also add the above text in the manuscript as suggested.

4. In general the language is clear, however there are some grammar errors which need to be carefully revised before publication.

Response: We proofread the manuscript and revised grammar errors in the text carefully, as suggested.

References

Liu F, Zhang Q, Zheng B, et al. Recent reduction in NO x emissions over China: syn-

thesis of satellite observations and emission inventories[J]. Environmental Research Letters, 2016, 11(11): 114002.

Ministry of Environmental Protection of China (MEP): 2013 Report on the State of Environment in China, http://www.mep.gov.cn/gkml/hbb/qt/201407/t20140707_278320.htm (last access: 16 May 2016), 2014 (in Chinese).

Wu R, Bo Y, Li J, et al. Method to establish the emission inventory of anthropogenic volatile organic compounds in China and its application in the period 2008–2012[J]. Atmospheric Environment, 2016, 127: 244-254.

Xia Y, Zhao Y, Nielsen C P. Benefits of China's efforts in gaseous pollutant control indicated by the bottom-up emissions and satellite observations 2000–2014[J]. Atmospheric Environment, 2016, 136: 43-53.

Zhang L, Liu L, Zhao Y, et al. Source attribution of particulate matter pollution over North China with the adjoint method[J]. Environmental Research Letters, 2015, 10(8): 084011.

Zhang X Y, Wang Y Q, Niu T, et al. Atmospheric aerosol compositions in China: spatial/temporal variability, chemical signature, regional haze distribution and comparisons with global aerosols[J]. Atmospheric Chemistry and Physics, 2012, 12(2): 779-799.

Zhang X Y, Wang J Z, Wang Y Q, et al. Changes in chemical components of aerosol particles in different haze regions in China from 2006 to 2013 and contribution of meteorological factors[J]. Atmospheric Chemistry and Physics, 2015, 15(22): 12935-12952.

Zhao B, Wang S X, Xing J, et al. Assessing the nonlinear response of fine particles to precursor emissions: development and application of an extended response surface modeling technique v1. 0[J]. Geoscientific Model Development, 2015, 8(1): 115-128.

Zhao Y, Zhang J, Nielsen C P. The effects of energy paths and emission controls and standards on future trends in China's emissions of primary air pollutants[J]. Atmospheric Chemistry and Physics, 2014, 14(17): 8849-8868.

Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-601, 2016.

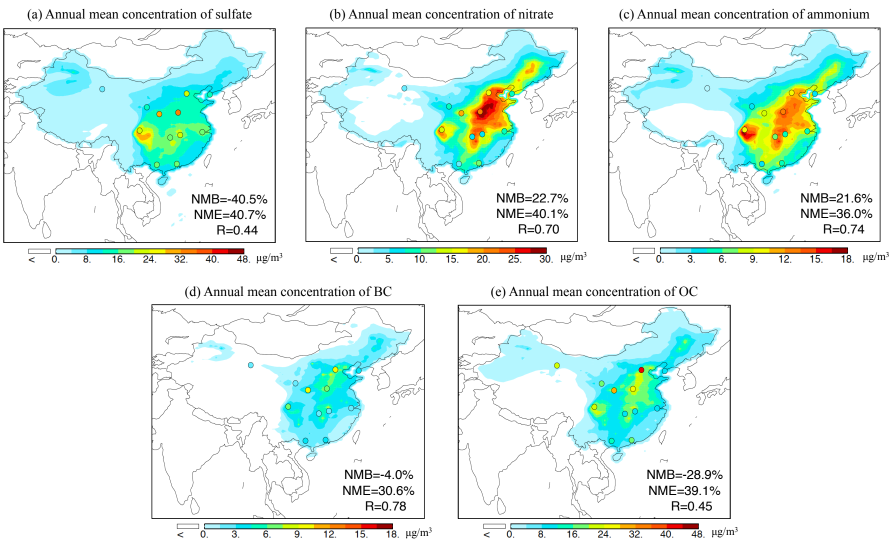

Figure 1 Comparisons of simulated $PM_{2.5}$ composition with observation averaged during 2012-2013

Fig. 1.

Table 1 Comparisons with other studies on recent air pollutant emissions in China (kt)

	SO_2	NO_X	PM_{10}	$PM_{2.5}$	VOCs
This study	23150	25638	16521	12155	23366
MEP, 2014	20439	22273	-	-	-
Liu et al., 2016	-	28300	-	-	-
Xia et al., 2016	23014-26884	28002-28817	-	-	-
Wu et al., 2016 (2012)*	-	-	-	-	29850
Zhao et al., 2014 (2015)*	26792	27511	15599	11419	-

*The year of emission are marked in brackets when it is different from the year of emission (2013) in our study.

Fig. 2.