Atmos. Chem. Phys. Discuss., 10, C13530–C13544, 2011
www.atmos-chem-phys-discuss.net/10/C13530/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Projections of air pollutant emissions and its impacts on regional air quality in China in 2020" *by* J. Xing et al.

J. Xing et al.

wangshuxiao@tsinghua.org.cn

Received and published: 12 February 2011

We would like to thank Reviewer 2 for a very thoughtful and detailed review of our manuscript that helped to improve the paper. Here we address all the points raised by the respectful reviewer as follows. We basically followed all the comments and revised manuscript accordingly. Revised manuscript with revised part in yellow background was also uploaded as a supplement.

1. An important contribution of this research is the development of scenarios that reflect real policy options for controlling air pollution in China. However, the method is not described in sufficient detail. (1) First, why is logistic regression selected for forecasting fuel consumption, as in Figure 1? If the forecast variable is fuel consumption in units of energy, a logistic function seems like a poor fit. But if the forecast variable is fraction of

industrial sector using a specific process, then logistic regression is a reasonable tool. Please be more specific.

Reply: We are sorry about the confusion. We used the logistic regression method to predict the population, GDP and industrial production of specific products. The energy forecast (i.e., energy demand projection, energy efficiency estimation and technology selection) were estimated by Integrated Policy Model for China (IPAC-AIM/local model). The details about the forecast of future activities are explained as follows.

(a) Population.

The national population projections for the year 2010 to 2020 were completely adopted from the Research Report on National Population Development Strategy (NPDSR, 2007), i.e., 1.36 and 1.45 billion in 2010 and 2020. The provincial populations were forecasted using the historical data from 1995 to 2005 through the logistic regression method. Minor adjustment was conducted to make the total of provincial populations to be consistent with the national population.

(b) Gross Domestic Product (GDP, in year 2000 prices)

The provincial GDP growth rates from 2006 to 2010 were attained from the 11th five-year plan enacted by the local provincial governments (http://www.gov.cn/test/2006-07/25/ content_344715.htm, in Chinese). The provincial GDP growth rates from 2010 to 2020 were forecast using the logistic regression method according to the historical data from 1996 to 2005. The average annual growth rate of national GDP was calculated from the provincial data, which was in line with the Reference Scenario in IEA report, i.e., 7.7% during 2005-2015 and 6% over 2005-2030 (IEA, 2007).

(c) Activity data

The energy forecast (i.e., energy demand, energy efficiency estimation and technology selection) were estimated by IPAC-AIM/local model, a bottom-up model with sectors classification and more than 100 technologies. The model searches for the least-cost

ACPD
10, C13530–C13544, 2011

technology mix to meet the given energy service demand (including five major sectors such as industry, agriculture, service, residence, and transportation, which are further divided into sub-sectors). The up-to-date information on these technologies was collected from large number of literature. (Jiang and Hu, 2006; Jiang et al., 2009)

We developed two energy scenarios, a reference scenario (REF) which was based on current development trends, and a policy scenario (PC) which assumed that more sustainable energy development strategies would be adopted in the future. Baseline scenario gives a basic trend to describe future economic activities. Only existing legislations on energy and environment will be implemented. Various energy and emission control policies are assumed for the policy scenario. In the policy scenario, policies on energy conservation, renewable energy will be widely adopted by both regulation and financial incentives. Economic structure change is also considered.

Projection of electricity generation considers the use of different energy and technologies. The development of renewable energy sources followed the national targets in the 11th Five-Year Plan (NDRC, 2008). The future development of hydro power, nuclear power and other renewable resources, the improvement of thermal efficiency, as well as the fuel structure have been considered in the model. The annual nuclear generation will be 260-280 billion kWh in 2020, according to the 'long-term development plan of nuclear power' reported by NDRC (NDRC, 2007). The hydro power will be developed in west China. The west-east gas transmitting project will promote natural gas power plants in the future. But the coal will still be the dominant fuel for power plant, which account for 95.3% and 93.6% in 2020REF and 2020PC, respectively. The power generation technologies include sub-critical units with a thermal efficiency of 30-36%, super-critical units with a thermal efficiency of 41%, ultra-supercritical units with a thermal efficiency of 43%, and IGCC (Integrated Gasification Combined Cycle) with a thermal efficiency of 45-55%. Before 2005, sub-critical units are the dominant technology. Super-critical units are widely applied since 2005. Ultra-supercritical units and IGCC will be promoted in the next five years. Closing the small units is another

ACPD
10, C13530–C13544, 2011

policy to improve the energy efficiency of power sector. Considering the promotion new technologies, the thermal efficiencies are assumed to increase to 37.5% in 2020 REF and 38.5% in 2020 PC scenario.

Primary energy demand is related to energy service demand of each subsector driven by the socio-economic growth (i.e., population, GDP, lifestyle, etc), and also influenced by the technology progress, energy efficiency as well as the transition of energy and industry structure.

For industrial sectors, in general, the comprehensive energy consumption will reach the levels of developed countries in 2020. The comprehensive energy consumption in steel production, non-ferrous metal smelting, ethylene, ammonia synthesis, and cement production will decrease by 18%, 7%, 29%, 27% and 33% respectively in 2020, compared to that in 2000, according to the 'energy-saving in long-term and special program' reported by NRDC (NRDC, 2004). The ratio of coal in energy structure will decrease, and the ratio of natural gas and electricity will slightly increase. The ratio of Circulating Fluidized-Bed (CFB) boiler used in industry will increase from 10% in 2005 to 15% in 2020, since CFB is more efficient and emits less SO2/NOx than grate boiler.

For domestic sources, along with the increase of the per capita income of rural residents, cleaner fuel will be promoted. In developed regions (e.g., Beijing, Tianjin, Shanghai), coal will be replaced by nature gas and electricity. In less developed regions where biomass is the major energy type, the biomass is going to be replaced by coal or gas and electricity. According to the 'energy-saving in long-term and special program', energy saving in constructions, commercial and residential sectors has also been considered, including design of energy saving building and energy-saving appliances promotion.

For mobile sources, the vehicle populations of truck, car, and motor cycle, as well as passenger or freight traffic volume of inland water and railroad, are driven by the socio-economic growth. The energy consumptions in transportation sector are also

ACPD
10, C13530–C13544, 2011

influenced by the changes of vehicle types and fuel economy. Those parameters are mainly referred to He et al. (2005), Wang et al. (2007) and IEA (2007). There is a continuous growth trend of larger trucks for long-distance freight transportation and a trend in rapid growth in light and mini vehicle fleets, while the medium-size trucks will decline greatly. Besides, the share of diesel vehicles in the Chinese vehicle fleet will increase, since diesel vehicles have better fuel economy than gasoline vehicles. Passenger car ownership will experience exploding growth due to rapid growth of private vehicles. To improve the fuel economy, Chinese government released a series of energy consumption standards for vehicles, such as the 'limits of fuel consumption for passenger cars' in 2004, 'limits of fuel consumption for light duty commercial vehicles' in 2007, 'low-speed goods vehiclesâĂŤlimits and measurement methods for fuel consumption' and 'Tri-wheel vehiclesâĂŤlimits and measurement methods for fuel consumption' in 2008. Fuel economy of car, truck, motorcycle, and agriculture transport machine will increase by 30%/40%, 25%/36%, 30%/36%, and 15%/23% in 2020REF/PC scenarios, compared to that in 2005. According to the 'energy-saving in long-term and special program' reported by NRDC (2004), the comprehensive energy consumption in railroad will reduce from 9.65tce/(Mt.km) in 2005 to 9.00 tce/(Mt.km) in 2020.

The industrial process sector is forecast based on the population and GDP projections. The logistic model was used to forecast the total industrial production in China. The industrial production was considered to be related to the industrial development level represented by the industrial added value (Jiang and Hu, 2006). The model parameters were solved from the historical data from 1996-2005. The quantity of provincial industrial product was forecast by their respective ratios in the total industrial product. The renovation of technology has been considered. According to the 'Suggestions on speeding up the cement industry structure adjustment' released by NRDC (2006), the advanced precalcining kilns will take up 70% of total cement production by 2010. The units with out-of-date technology (i.e., Earth kiln) in lime plants will be phased out (Liu and Yin, 2004; CLA, 2005). Chinese government has announced to phase out the indigenous coke production by 2010. Advanced technologies in nitric acid and sulfur

ACPD

10, C13530–C13544, 2011

acid plants are promoted in the future.

Reference

CLA (China Lime Association), Report on Chinese lime industry development in the first half of 2005, 2005. (in Chinese)

National Population Development Strategy Research (NPDSR), Research Report on National Population Development Strategy, Population research, 2007, 31(1), 1-10 (in Chinese) IEA (International energy agency), World energy outlook 2007[M], Paris, 2007

He K B, Huo H, Zhang Q, et al. Oil consumption and CO2 emission in China's road transport: current status, future trends, and policy implications[J]. Energy policy, 2005, 33(12): 1499-1507

Jiang, K.-J., Hu, X.-L. Energy demand and emissions in 2030 in China: scenarios and policy options, Environmental Economics and Policy Studies; 2006, 7(3), 233-250

Jiang, K.-J., Hu, X.-L., Zhuang, X., Liu, Q. China's Low-carbon Scenarios and Roadmap for 2050, SINO-GLOBAL ENERGY, 2009, 14(6), 1-7 (in Chinese)

Liu Q.S., and Yin, B.M. Cement industry economic circumstance analysis in 2003 and prospects of 2004, CHINA BUILDING MATERIALS, 2004. 1(in Chinese)

NDRC (National Development and Reform Commission), energy-saving in long-term and special program, 2004 (in Chinese)

NDRC (National Development and Reform Commission), some suggestions on speeding up the cement industry structure adjustment, 2006 (in Chinese)

NDRC (National Development and Reform Commission), long-term development plan of nuclear power (2005-2020), 2007 (in Chinese)

NDRC (National Development and Reform Commission), "11th five-year" plan for re-

ACPD

10, C13530–C13544, 2011

Interactive Comment

newable energy development, 2008 (in Chinese)

Wang C, Cai W J, Lu X D, et al. CO2 mitigation scenario in China's road transport sector[J]. Energy Conversion and Management, 2007, (48): 2110-2118

(2) Second, to what extent are the scenarios different from the "official Chinese Industrial Forecast", listed as one of the data sources? Can you be more specific about how these data sources are used?

Reply: The "official Chinese Industrial Forecast" includes 'the 11th five-year plan' of each province, 'the 11th five-year plan for renewable energy development', 'energy-saving in long-term and special program', 'long-term development plan of nuclear power (2005-2020)'. We followed those sources in both scenarios during the forecast. Details are given as follows. The provincial GDP growth rates from 2006 to 2010 were attained from the regional 11th five-year plan enacted by the provincial governments. The development of renewable energy sources followed the national targets in the 11th Five-Year Plan of NDRC (2008). The annual nuclear generation will be 260-280 billion kWh in 2020, according to the 'long-term development plan of nuclear power' reported by NDRC (2007). The comprehensive energy in steel production, non-ferrous metal smelting, ethylene, ammonia synthesis, and cement production will decrease by 18%, 7%, 29%, 27% and 33% respectively in 2020, compared to that in 2000. The comprehensive energy consumption of railway transport will reduce from 9.65tce/(Mt.km) in 2005 to 9.00 tce/(Mt.km) in 2020, according to the 'energy-saving in long-term and special program' reported by NRDC (2004).

(3) Third, these questions are not addressed in the referenced reports by Amman et al. Is there a better source? There are two reports by Amman et al. published in 2008 listed in the references section; please make the citations unambiguous.

Reply: The reference should be Amman et al., 2008a. We also provided the details about activity forecast in the revised manuscript.

2. For the scenario generation, is the economic growth assumed to be equal across all Provinces? It is not clear from Table 2. Are the data sources described in Section 2.1 at the Province or the National level? It would be good to include a few sentences clarifying the extent to which your estimates capture regional differences in growth and application of abatement technologies.

Reply: The economic growth is not equal across all provinces. In the scenario development, we assumed the provincial economic growth level. The provincial GDP growth rates during 2006∼2010 were assumed according to the regional 11th five-year plan enacted by the provincial governments (http://www.gov.cn/test/2006-07/25/content_344715.htm, in Chinese). The provincial GDP growth rates during 2010∼2020 were projected using the logistic method based on the historical data of each province from 1996 to 2005. The energy use (i.e., energy service demand projection, energy efficiency estimation and technology selection) were estimated by IPAC-AIM/local model, a bottom-up model with sectors classification and more than 100 technologies for 31 regions of China. However, the application of abatement technologies is assumed same across all provinces. We have clarified it in the revised manuscripts.

3. Hong Kong and Macao are not part of the scenarios. Yet the Pearl River Delta is a featured area for the analysis of the concentration changes. Do the emissions in Hong Kong and Macao impact this region? What was assumed for the emissions in Hong Kong and Macao? Reply: In the future scenarios, the impacts from the emissions of Hong Kong and Macao has been assumed as the same as 2005 baseline scenario. And their baseline emissions are obtained from the INDEX-B datasets (Zhang et al, 2009).

Reference

Zhang, Q., Streets, D.G., Carmichael, G.R., He, K.-B., Huo, H., Kannari, A., Klimont, Z., Park, I. S., Reddy, S., Fu, J. S., Chen, D., Duan, L., Lei, Y., Wang, L. -T., Yao, Z.-L., 2009a. Asian emissions in 2006 for the NASA INTEX-B mission, Atmos. Chem. Phys.

ACPD

10, C13530–C13544, 2011

Interactive Comment

9, 5131-5153.

4. The CMAQ modeling experiment description is confusing, starting on page 26906, line 14 with "Except for the 2005 emissions and four...". These sentences are critically important as they describe the emission scenarios that make up this modeling experiment. Yet these sentences are very difficult to understand. Please re-write. After reading it several times, I gather that the 25 simulations include – 1 control study based on 2005 emissions – 4 future scenarios meant to represent hypothetical 2020 emissions – 20 additional scenarios, where one pollutant is set to the scenario level and the rest are held at the 2005 level, but I'm not sure about this last one. Please explain more explicitly.

Reply: We have modified the manuscript according to the reviewer's comments, as follows. "Air quality impacts from emission changes for all species are calculated using the above MM5/CMAQ modeling system. Three fast-developing city clusters, North China Plain (NCP) centralized with Beijing-Tianjin-Tangshan, Yangtze River delta (YRD), and Pearl River delta (PRD), have been chosen as the target areas. The 2005 baseline scenario and two future scenarios (i.e., high-emission scenario REF[0] and low-emission scenario PC[2]) has been simulated with CMAQ. Besides, in order to explore the control benefit from each pollutant control, we have conducted 10 additional scenarios, where one pollutant is set to the two future scenario level (i.e., REF[0] and PC[2]) and the rest are held at the 2005 level. The air quality responses are defined as the percent change in 2020 scenarios relative to the 2005 scenario, at average regional level."

5. The notation describing the results is confusing in part because a "concentration response" is not defined. For example, page 26906, line 27: "NO2 concentration responses are 0.9e1 in NCP" Is this a mean, quartile, or the absolute range of the response? Is the response the ratio of one scenario to another? Also, please use the en dash (–) to denote a range, rather than the tilde (e). I suggest defining notation and a response in the start of this section and use it throughout.

ACPD

10, C13530–C13544, 2011

Reply: We agree with the reviewer that it's necessary to give the definition of the notation explicitly. We have revised the manuscript as follows. "The air quality responses are defined as the percent change in 2020 scenarios relative to the 2005 scenario, at average regional level."

6. "Concentration responses of SO_2 and NO_2 to the changes of SO_2 and NO_x emissions present near-linear relationship ... NO_2 concentrations present slightly nonlinear relationships with NO_2 emission changes. The ratio of emission changes to NO_2 concentration responses are 0.9e1 in NCP, and 1e1.5 in YRD and PRD." It seems the first sentence states that SO_2 and NO_2 concentrations change nearly linearly with emissions. Then, the later sentence states that NO_2 is slightly not linear, and then the calculated ratios are as large as 1.5. Is this non-linear behavior? The NO_x concentration and lifetime depends on OH, and there are strong feedbacks of NO_x onto OH, so one would expect to find many cases where the NO_2 concentration does not scale linearly with a change in NO_x emissions.

Reply: Yes, the NO_2 concentration does not scale linearly with the change in NO_x emissions. As the reviewer pointed out, the NO_2 concentrations are strongly affected by the OH level, therefore the NO_2 concentration responses are different in three regions. We have modified the statement in the revised manuscript, as follows. "Following the continual increase of SO_2 and NO_x emissions in REF[0], compared to that in 2005, the SO_2 and NO_2 concentration will increase in most of areas (averagely by 28% and 41% domainwide), particularly higher in southeast coastal provinces, inter-Mongolia and Shanxi which have large increase of energy use in industrial boilers and transportation. The effects of control measures can be seen from the reduction of SO_2 and NO_2 concentration in PC[2]. In PC[2], compared to that in 2005, SO_2 concentrations will decrease by 18% domainwide, and NO_2 concentrations in most of areas over east China are same as those in 2005. But slight increases are found in southeast coastal provinces. More strengthen policy should be conducted focused on those area. Concentrations of SO_2 and NO_2 are mainly affected by their primary emissions,

ACPD
10, C13530–C13544, 2011

as shown in Fig. 6, which indicates that control of the relative primary emissions is an effective way to reduce these two pollutants."

7. The ozone changes reported in Section 3.3 are difficult to understand, because it is unclear which scenario is being described. For example, the second sentence begins with "Due to the increase of future NMVOC ...", but the control scenarios have large decreases in NMVOC. I suggest that the reader should be directed to Figure 6 to read the results from the different scenarios, and then this section should focus in more detail on determining if ozone in these regions / seasons is more sensitive to NMVOC or NOx emission reductions.

Reply: All changes are compared with the 2005 baseline scenario. To make it clear, we follow the reviewer's suggestion to provide the details about the ozone sensitivities to NOx and VOC and rewrite this discussion as follows. "The ozone concentrations have strong seasonal variations. Ozone concentration is higher in April and July for most of areas over east China. Besides, higher ozone concentration also appears in October in PRD. Due to the growth of NOx and VOC emissions in REF[0], ozone concentrations in most of areas over east China increase significantly in July. Besides, ozone concentrations in south China also increase in April and October. In July, the combined effects of NOx and VOC emission growth on ozone concentrations are 8% domain-wide, compared to that in 2005. Because of the titration reaction of NO to NO2 and the VOC-limited regime (excess NO2 consumes OH to generate HNO3), ozone concentrations decrease significantly in January for all areas and in April and October for north China and megacities (i.e., Guangzhou). These results suggest that the effects of different ozone chemistry regimes in different seasons should be considered during NOx control policy-making. It is better to strictly control NOx emissions in summer (in summer and fall for PRD) to obtain maximal ozone reduction benefits."

8. The PM2.5 section is also difficult to understand, in part because it is not clear what a "concentration response" is. Sentences such as "PM2.5 concentration responses to the decrease of PM emissions are 1.5e1.8 in January" are hard to interpret. Also,

ACPD

10, C13530–C13544, 2011

Interactive Comment

I don't know what this sentence means: "Sensitivity of PM2.5 concentration to SO2 emissions is larger in July with scale as 3, lower in January with the scale as 10". I advise the authors to re-write this section, letting Figure 7 show the change in PM2.5 for each scenario and species, and then using the text to explain what emissions source reductions can lead to the largest changes in PM2.5.

Reply: We follow the reviewer's suggestion to rewrite this section. "The future PM2.5 concentrations are significantly affected by the changes of its precursor emissions (i.e., SO2, NOx, NH3, NMVOC and PM). In REF[0], the PM2.5 concentration will slightly increase by 8% domainwide mainly because of the growth of SO2, NOx and NH3 emissions, especially in April, July and October. Reduction of primary PM emission can compensate some increases of PM2.5 concentration. Based on the stepped reductions from REF[0] to PC[2], the PM2.5 concentration will decrease by 16% domainwide. Reduction of primary PM emissions plays the most important role in the decrease over China. Because of the increase of SO2 emissions in REF[0], sulfate concentrations increase by 7% domainwide. In PC[2], stricter controls of SO2 emissions reduce sulfate concentration by 14% domainwide, while sulfate concentration in PRD slightly increases 9% because of the increase of SO2 emissions. The growth of NOx emissions has positive impacts on the sulfate reduction because of the ozone chemistry, especially in January, April and October when VOC-limited regimes are dominating. Extra NOx emission will react with OH to obstruct its reaction with SO2 to generate sulfate. Growth of NH3 emissions contributes to a 3% increase in sulfate domainwide. In REF, the increase of emissions in REF[0] will increase the nitrate concentration by 40% domainwide, especially in April and July when atmospheric oxidization is strong and the biogenic VOC emission is large. NOx emissions are the dominate contributor, and the growth of NH3 and SO2 emissions also contributes to some increases of nitrate concentration. In PC[2], which applies stricter controls on NOx emissions, the nitrate concentration will be kept as the same level as 2005 over China, though slight increase shown in YRD and PRD."

ACPD

10, C13530–C13544, 2011

9. The interpretation of the deposition section is also very confusing. For example, page 26910, line 15 "impacts from NOx emissions are relative small, with a scale of 5..." It is not clear what scale refers to. Also, the magnitude of the changes are pretty similar to the ammonia emission changes, so why the conclusion that NOx is relatively small? This analysis doesn't inform if the NH3 is more or less effective than NOx controls. Rather, it compares two scenarios, each of which have different relative changes in NOx and NH3 emissions.

Reply: The "scale" means the ratio of NOx emission changes to the PM2.5 concentration response. The total impacts of NOx emission changes are similar to the ammonia emission changes, but the NOx emission changes are much larger than NH3, therefore the impact of unit NOx reduction is smaller than that of NH3. In another word, NH3 control is more effective than NOx controls. We have revised the statement as follows. "Because of the increase of SO2 emissions in REF[0], total sulfur deposition will increase by 19% domainwide, especially higher in YRD and PRD. In PC[2], compared to that in 2005, stricter controls on SO2 emission will reduce the total sulfur deposition by 15% domainwide. Both NOx and NH3 emissions have large impacts on the total nitrogen deposition. In REF[0], the total nitrogen deposition will improve by 25% domainwide. In PC[2], which stricter controls on NOx emissions are applied and NH3 emissions are kept as 2005 level, the total nitrogen deposition will only present slightly increases by 2% domainwide."

10. Given that I had such a difficult time interpreting the results, I'm not sure what to make of the conclusions. But I suggest that the authors focus on what air quality problems are likely to persist despite substantial emission controls, and what emission sources and sectors could be targeted to mitigate those air quality problems.

Reply: We follow the reviewer's suggestion and rewrite the conclusion as follows. "Because of the rapid growth of the economy and population, China's energy consumption by power plants and industries is predicted to double, and on-road transport is expected to be triple by 2020. Improvement of air quality is a big challenge that China is

ACPD
10, C13530–C13544, 2011

facing. It's urgent for the government to find possible solutions to reduce the primary emissions in order to protect human health and the ecosystem. Based on current control legislation and proposed control (as in REF[0]), the emission of SO2, NOx, VOC and NH3 will increase by 17%, 50%, 49% and 18%, respectively, in 2020, while PM will be reduced by 10% over East China, compared to those in 2005. That will lead to a significant impact on air quality. CMAQ simulations indicate that the concentration of SO2 and NO2 will increase by 28% and 41% domainwide in annual mean level. The daily 1-h maximum concentration of ozone in summer will increase by 8%. The concentration of sulfate and nitrate will increase by 7% and 40%. In addition, total sulfur depositions are predicted to increase by 19% and 25%, respectively. A detailed step-by-step control implementation plan has been designed in this study. Initially a more sustainable energy development strategy to improve energy efficiency needs to be adopted; this will bring a reduction in the emissions of SO2, NOx and PM10 by 4.1 Tg, 2.6 Tg, and 1.8 Tg, respectively. Second, better implementation of current control policies is needed and methods need to be adopted to ensure the emission sources meet the emission standard; this will reduce SO2, NOx and PM10 emission by 2.9 Tg, 1.8 Tg, and 1.4 Tg, respectively. Third, stricter policy standards need to be adopted to promote the applications of advanced control technologies; this will reduce SO2, NOx and PM10 emission by 3.2 Tg, 3.9 Tg, and 1.7 Tg, respectively. In the strict emission control scenario (PC[2]), the SO2 and PM10 emissions will decrease by 18% and 38%, compared to those in 2005, while the NOx and VOC emissions will increase by 3% and 8%, respectively. NH3 emissions are kept at same level as those in 2005. After all the substantial emission controls, the future air quality is able to maintain as 2005 level, over East China, while the southeast coastal provinces and inter-Mongolia and Shanxi, need more strengthened control actions on the SO2 and NOx emisssoin in industry boiler and transportation. While NH3 has not been considered in the current air pollutant control strategy in China, its impact on PM2.5 concentrations is important. In addition, NH3 emissions have significant impacts on total nitrogen deposition in the future. NH3 emission controls should be considered as well."

ACPD

10, C13530–C13544, 2011

Interactive Comment

11. For Figure 4, I suggest changing the scale such that all ratios less than one are in shades of green and all greater than one are in shades of red / orange.

Reply: We follow the reviewer's suggestion to change the scale color of this figure.

12. For Figures 6, 7, and 8: please define "response" in the caption and relevant parts of the text as the percent change relative to the 2005 scenarios.

Reply: We follow the reviewer's suggestion to revise the captions of those figures as follows. "Fig. 7 Percent changes of surface concentration of gas species relative to the 2005 scenarios in 2020; Fig. 8 Percent changes of surface PM concentrations relative to the 2005 scenarios in 2020; Fig. 9 Percent changes of total S/N-deposition relative to the 2005 scenarios in 2020"

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/10/C13530/2011/acpd-10-C13530-2011-supplement.pdf

---

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 26891, 2010.

ACPD

10, C13530–C13544, 2011

Interactive Comment