

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.

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We would like to thank Reviewer 1 for a very thoughtful and detailed review of our manuscript that helped to improve the paper. 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) Page 26906, line 22, Are the calculated concentrations of SO₂ and NO₂ at ground level or the average concentrations of SO₂ and NO₂ in the boundary level? The same comment is applicable for other pollutants.

Reply: The calculated concentrations of SO₂ and NO₂ are at ground level, as well as

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O3 and PM species. We have clarified this in the revised manuscript.

2) Page 26906, lines 25 to Page 26907, line 1, this reviewer totally lost on the discussion. This reviewer believes that primary emission of NO₂ should account for a minor fraction of NO_x emission. NO₂ should be dominantly from the conversion of NO to NO₂. The analysis of the ratio of emission changes of NO₂ to NO₂ concentration responses does not make sense to this reviewer.

Reply: We are sorry this was a typo. It should be "NO₂ concentrations show a slightly non-linear relationship with NO_x (NO+NO₂) emission changes. The discussions have been modified in the revised manuscript, as follows. "Concentrations of SO₂ and NO₂ are mostly affected by SO₂ and NO_x emissions, as shown in Fig. 6, which indicates that the control of the relative primary emissions is an effective way to reduce these two pollutants."

3) Page 26907, lines 1-3, this reviewer do not understand what the authors were discussing.

Reply: The modeling results indicate that growth of VOC emissions will slightly reduce NO₂ concentration by 2%. The possible reason is that enhanced VOCs provide more OH to react with NO₂ to generate HNO₃. We have revised this point in the revised manuscript.

4) Page 26907, lines 7-10, the authors should summarize the general trend rather than giving an example. The PRD, ECH, YRD and NCP are nuisance going back and forth in the manuscript to remember what these terms mean. It is unnecessary to save letters in writing.

Reply: Thanks for the kind suggestion. We have revised the terms except Pearl River Delta (PRD) and Yangtze River Delta (YRD), which are normally used in China.

5) Page 26907, lines 15-17, "Although in January, the increase of NO_x emission in REF[0] will reduce the ozone concentrations by 4% in NCP, 7% in YRD, 1% in PRD,

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and 1% in ECH.” Why? If it is due to the titration reaction, why not use concentration of (NO₂+O₃)?

Reply: It is due to the titration reaction, as well as the VOC-limited regime (excess NO₂ will consume OH to generate HNO₃). We agree with the reviewer it's better to use concentration of (NO₂+O₃). Consider that we have already discussed the NO₂ concentration, we focus on the ozone sensitivities to NO_x and VOC, 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 NO_x 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 NO_x and VOC emission growth on ozone concentrations are 8% domain-wide, compared to that in 2005.”

6) Page 26907, lines 20-22, “These results suggest that the effects of different ozone chemistry regimes in different seasons should be considered during policy-making for NO_x control.” What does it means?

Reply: Considering that the ozone concentration has different response to NO_x and VOC emissions, it is better to strictly control NO_x emissions in summer (in summer and fall for PRD) to obtain maximal ozone reductions. We have modified this sentence in the revised manuscript, as follows. “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 NO_x control policy-making. It is better to strictly control NO_x emissions in summer (in summer and fall for PRD) to obtain maximal ozone reduction benefits.”

7) Page 26908, lines 1-3, an increase or a decrease relative to what?

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Reply: The increase or decrease in the paper is relative to the 2005 Baseline. We have clarified this in the revised manuscript, as follows. “The air quality responses are defined as percent change of 2020 scenarios relative to the 2005 scenario, at average regional level.”

8) Page 26908, lines 8-9, “PM_{2.5} concentration is more sensitive to primary PM emissions in January due to lower atmospheric oxidation activities” The meaning of this sentence is not clear to this reviewer.

Reply: The simulation results indicate that primary PM emissions have larger impacts on PM_{2.5} concentrations in January, compared to other month. That’s because of the relatively larger percentage of primary components in PM_{2.5} concentrations due to the low atmospheric oxidation. We have modified this sentence as follows. “The future PM_{2.5} concentrations are significantly affected by the changes of its precursor emissions (i.e., SO₂, NO_x, NH₃, NMVOC and PM). In REF[0], the PM_{2.5} concentration will slightly increase by 8% domainwide mainly because of the growth of SO₂, NO_x and NH₃ emissions, especially in April, July and October. Reduction of primary PM emission can compensate some increases of PM_{2.5} concentration. Based on the stepped reductions from REF[0] to PC[2], the PM_{2.5} concentration will decrease by 16% domainwide. Reduction of primary PM emissions plays the most important role in the decrease over east China.”

9) Page 26908, lines 11-12, “decreases in SO₂ emissions in PC[2] reduce the PM_{2.5} concentrations by 5% in NCP, 1% in YRD, and 3% in ECH.” The statement is problematic since an increase of SO₂ emissions in PC[2] in the Pear River Delta shows in Table 6.

Reply: We have revised the statement as follows. “Because of the increase of SO₂ emissions in REF[0], sulfate concentrations will be enhanced by 7% domainwide. In PC[2], impacts from stricter controls of SO₂ emissions will reduce sulfate concentration by 14% domainwide, however, the sulfate concentration in PRD will slightly increase

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by 9% because of the increase of SO₂ emissions.”

10) Page 26908, lines 17-19 “NO_x controls are more effective in April and July in NCP/YRD with an emission to concentration scale of 6 12, while are less effective in PRD with scale >20 due to NH₃-poor condition.” This reviewer cannot follow the logic of the statement. The sentence should be clarified.

Reply: We have modified this sentence to clarify in the revised manuscript as follows. “In REF, the increase future emissions in REF[0] will enhance the nitrate concentration by 40% domainwide, especially in April and July when atmospheric oxidization is strong and the biogenic VOC emission is large. NO_x 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 applied stricter controls on NO_x emissions, the nitrate concentration will be kept as the same level as that in 2005 over China, though slight increase shown in YRD and PRD.”

11) Page 26908, line 27 “SO₂ is the dominate sulfate species in PM_{2.5}.” The sentence is problematic.

Reply: We have revised it as follows. “Because of the increase of SO₂ emissions in REF[0], total sulfur deposition will be enhanced by 19% domainwide. In PC[2], compared to 2005, stricter controls on SO₂ emission will reduce the total sulfur deposition by 15% domainwide.”

12) Page 26909, lines 4-7 “The growth of NO_x 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 NO_x emission will react with OH to obstruct its reaction with SO₂ to generate sulfate; the reduction ratio of sulfate is 6%.” This reviewer lost here and this reviewer believes NO_x emissions should, in general, increase OH in the regional scale, although it may be not the case in urban center.

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Reply: The response of OH radical to the NO_x emissions is strongly related to the NO_x-/VOC-limited regimes. In VOC-limited regime, the increase of NO_x emissions will significantly reduce OH level. In this part we select the monthly mean value in daily-average scale (including both day and night). The increase of NO_x emissions reduce the OH radical even in regional scale. We have modified this discussion as follows. “The growth of NO_x 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 NO_x will react with OH to obstruct its reaction with SO₂ to generate sulfate.”

13) The section of “Total sulfur deposition and nitrogen deposition” is difficult to be understood because the two terms are not defined in this manuscript.

Reply: In this paper, the total sulfur deposition is defined as the wet and dry deposition of SO₄²⁻ and SO₂ (all counted by S); the total nitrogen deposition is defined as wet and dry deposition of NO₃⁻, HNO₃, NH₃, N₂O₅, NO, NO₂, peroxyacetyl nitrate (PAN), HONO, organic nitrate (NTR) (all counted by N). We have clarified the definition in the revised manuscript.

Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/10/C13515/2011/acpd-10-C13515-2011-supplement.pdf>

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

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