* Comments in black, Times New Roman, 12
* Authors’ reply in blue, Times New Roman, 12
* Revision in manuscript in blue, Calibri, 11

**Interactive comment on “Feasibility and difficulties on China new air quality standard compliance: PRD case of PM2.5 and ozone from 2010 to 2025” by H. Liu et al.**

**Anonymous Referee #1**

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First Referee Comment

RE: Feasibility and difficulties on China new air quality standard compliance: PRD case of PM2.5 and ozone from 2010 to 2025 H. Liu, X. M. Wang, J. M. Pang, and K. B. He

Atmos. Chem. Phys. Discuss., 13, 20923-20959, 2013 www.atmos-chem-physdiscuss.net/13/20923/2013/ doi:10.5194/acpd-13-20923-2013

General Comments: The present manuscript explores an important issue that would connect science and control policy in China in a timely manner. Naturally, the challenges to any authors to articulate all relevant issues in a concise paper with due consideration of the feasibility and difficulties is real and obvious. This is a good first attempt but substantial revision work to improve the quality of the paper is also needed.

For now, compelling evidence to project and substantiate PM (both PM2.5 and PM10) compliance to China national standards in PRD is lacking. The notion that in the northern part of China only PM (PM2.5 and PM10) presents a challenge, in terms of compliance with the national standards, owing to high levels of PM should be reviewed more carefully. In other words, ozone may also be a problem in the north as well. With the availability of air quality data both on regional and national levels, the authors should pay more attention of data analysis and come up with a more robust case. This effort might reveal that in the northern part of China, it has both PM and ozone (high oxidizing environment) problems. In that case, the control strategies might be very different.

Thank you for the comments! Based on your comments, we have made substantial revisions on this manuscript. Please review the new changes as specific replies.

Specific Comments: A good starting point to discuss the present manuscript would be reviewing carefully the abstract section.

1. As stated in the general comments section above, the authors should collect and review both PM2.5, PM10 and ozone data from the northern part of China and see if the statement “In north, PM2.5 and PM10 are still far beyond the standards. . ...In south, O3 goal is much challenged.” is still making sense. For PM2.5 and PM10, the current and projected compliance status for both annual and 24-hr standards from monitoring data and modeling work should be verified for the northern and southern parts of China; also the 1-hr and 8-hr ozone should be checked carefully for the north and PRD.

Accepted. In this revision, we cited the 74 cities air pollution report released by MEP recently to describe a picture of PM and O3 emissions in China. The new statement is based on air quality monitoring data in 74 cities in northern and southern parts of China. We made the following changes in manuscript:

“In China, especially the northern part, PM2.5 and PM10 are still far beyond the standards (Gao et al., 2011). The data on air pollution for the first six months in 2013 were released by MEP recently (Index: 000014672/2013-01270, www.zhb.gov.cn). The average concentration of PM2.5 (PM10) was 115 (193) µg m-3 in Beijing-Tianjin-Hebei (BTH) region. According to the new NAAQS, no city meets either PM2.5 or PM10 standard in this region. Yangzi-River-Delta (YRD) region reported 69 (103) µg m-3 PM2.5 (PM10) concentrations, while PRD that is near Hong Kong has lower concentration of about 44 (64) µg m-3. The ozone non-attainment rate (8-hr maximum concentration) was 5.0%~33.7%, 2.2~27.1% and 5.5~15.5% in BTH, YRD and PRD respectively. Ozone problem is one of the biggest challenges for those regions (Geng et al., 2009; Tie et al., 2009;Liu et al., 2010; Zheng et al., 2009a; Zheng et al., 2010).”

2. Information pertaining to the scientific evidence for calculating the emission reduction potential should be presented; sources of information should also be highlighted (e.g., reduction targets committed by local or regional authorities) and cited. This kind of information should augment with the reduction targets committed by Guangdong and Hong Kong governments for 2015 and 2020; and the framework agreement for 2020. With the availability of this kind of information, the readers would be better inform about the feasibility of complying with the PM2.5 and PM10 standards in 2025.

Accepted. We highlight sources of information committed by local or regional authorities in this revision about future emission controls. All the government documents announce action plans instead of reduction targets. We have added more details to explain how we estimate the future emissions based on those action plans. In section 3.1, the control targets, control principals and information sources are discussed. Those control measures are designed based on government plan from both local authorities and regional authorities. In section 3.2, the details of controls and how we convert control measures into emission reductions are provided. In addition, detailed quantified information about key assumption was provided.

Changes were made in section 3.1, includes the following:

“Emission control actions are designed based on a series clean air actions committed by local and regional authorities. The Guangzhou Municipal government is planning to introduce a series of control measures in future years, giving a strong impetus to the prevention and control of atmospheric pollution. Useful experience has been accumulated from the Guangzhou Asian Games for further regional joint prevention and control of air pollution. To substantially cut down emissions of atmospheric pollutants amid stable and rapid economic expansion, it necessitates a faster slump in the emission intensity per unit of GDP than what has been accomplished in the last two decades in order to offset the negative effects of rapid GDP growth on pollution reduction. The control measures before 2012 are from ‘Strengthened comprehensive implementation programs of prevention and control of air pollution after the Asian Games in Guangzhou’, while the measures between 2012-2016 reference ‘Comprehensive work plan of air pollution prevention and control in Guangzhou 2012-2016’ and ‘Total Emission Control Plan of Major Pollutants in Guangzhou during the Twelfth Five-Year Plan Period’.

The regional control is also considered in this research to provide a background emission inventory. To augment the analysis with local information, the following documents are referenced to develop the regional action plan. 1) before 2012: ‘Clean Air Action Plan in Pearl River Delta in Guangdong Province’, 2) from 2012 to 2020: the ‘Outline of the Plan for the Reform and Development of the Pearl River Delta (2008-2020)’, the ‘Regional Cooperation Plan on Building a Quality Living Area’, the ‘Jointly Prevention & Control of Regional Air Pollution in Pearl River Delta in Guangdong Province’, as well as the ‘Emission Reduction Plan for 2012~2020, Committed by the Framework Agreement between Guangdong and Hong Kong Governments’.”

3. Key assumptions of the MM5-STEM models employed in the present study should be clearly articulated. In addition, uncertainties analysis for data and model assumptions should be performed and reported in the paper.

Accepted. In this revision, we perform the model evaluation and key assumptions of the model in the present study in section 4.1.

For the key assumptions of the model in the present study, we made the following changes in manuscript:

“The MM5-STEM 2K3 modeling system was used in this study. MM5-STEM 2K3 is an integrated model system which combines the Sulfur Transport and Deposition Model version 2K3 (STEM-2K3) and the Penn State/National Center for Atmospheric Research (NCAR) Fifth-Generation Mesoscale Meteorological Model version 3.7 (MM5v3.7). It includes the SAPRC99 gaseous mechanism (Carter, 2000) with photolysis rates calculated using the online TUV model (Madronich and Flocke, 1999). It was used in the Transport and Chemical Evolution over the Pacific (TRACE-P) experiment (Tang et al., 2003; Carmichael et al., 2003) and performed well compared with observed data in the PRD region (Wang et al., 2005; Wang et al., 2013; Liu et al., 2013).”

For the uncertainties analysis for data and model assumptions, we deleted the following of the last version:

“The STEM model was evaluated for this region by comparing predicted daily concentrations for November 2010 against observation data measured by the Guangzhou Environmental Monitoring Center and by the Pearl River Delta Regional Air Quality Monitoring Network (Liu et al., 2013). In that study, the Mean Normalized Bias of NO2, SO2, PM10, PM2.5 and O3 are ranging from -51% to 4%, from -43% to 29%, from -56% to -20%, from -52% to -42%, from -31% to -6%, respectively. Meanwhile, the STEM model was also evaluated for the PRD region in November 2006 and November 2009. The evaluation yielded an index of agreement (IOA) of SO2 ranges of 0.86-0.98 in November 2006 and 0.81-0.96 in November 2009 (Wang et al., 2013).”

And added the uncertainties for data and model assumptions of this study as following:

“The STEM model was evaluated with six statistical metrics, i.e., average for observation (OBS) and simulation (SIM), absolute bias (ME), bias, root mean-square error (RMSE), and the index of agreement (IOA) , as calculated below, where Si stands for the simulation and Oi stands for the observation.

(1)

(2)

(3)

(4)

(5)

(6)

”

“Results of the statistical evaluation of daily maximum 8-hour average O3 (O3 8h-max), daily PM10 concentration and daily PM2.5 concentration over 10 sites located in Guangzhou are listed in Table 1 and Table 2. Fig. 10 compares the observed and simulated data for the 10 sites in January, April, July and October 2010. The IOA of the 3 pollutants are 0.60-0.95 (O3 8h-max), 0.76-0.99 (PM10), and 0.77-0.98 (PM2.5), respectively. During April and July, for PM10 and PM2.5, the IOA are ranging from 0.91 to 0.99 and from 0.86 to 0.98, shows a high agreement between simulation and observation. The results show that STEM-2K3 well simulated O3, PM10 and PM2.5 in April and July 2010 while slightly underestimated in January and October 2010, especially during October 19th-23th.”

Meanwhile, we added statistical evaluation of pollutants simulation in January, April, July and October 2010 with Table 1 and Table 2, comparison between observed and simulated concentrations of air pollutants (daily maximum 8-hour concentration of O3, PM10 and PM2.5) in January, April, July and October 2010 with Fig. 10.

4. “A comprehensive study. . .O3 vary in 7-25% from May to November.” Unclear which year the authors refer to these data and results.

Accepted. We mentioned at the beginning of this section that year 2010 was selected as the base year. In addition, we highlight in all the figures and relevant description that we refer to year 2010.

5. As the major themes of the paper are about PM2.5 and ozone, the problems are very much regional in nature. Nevertheless, for now, some key features of the successful regional cooperation between the governments in Guangdong and Hong Kong receive very little attention in the present paper. These key features can be summarized by two major points: 1, long-term regional cooperation by ways of sharing high quality data through operating the PRD regional network (see a PRD network paper cited below for reference); 2, data transparency – the scientists and the public can access the data and evaluate the effectiveness of key emission reduction measures or initiatives independently. In short, information pertaining to regional cooperation efforts would also tracks the evolution of industrial growth and emission control and provides an evidence-base air quality framework for the management of regional air quality problems.

RE: PRD regional air quality network paper and key regional initiatives

1. For further information about the PRD regional air quality network paper, please refer to the link and the article-in-press version of the paper below.

http://aaqr.org/Doi.php?id=AAQR-12-10-OA-0276\_proof

RE: Key regional initiatives currently not considered but highly relevant for the present paper: –

I. The Outline of the Plan for the Reform and Development of the Pearl River Delta (2008-2020) a) Chinese,

http://www.provost.cuhk.edu.hk/prvo/provost\_media/academic\_initiatives/PDR\_Framework\_Chin.pdf

b) English, http://www.provost.cuhk.edu.hk/prvo/provost\_media/academic\_initiatives/PDR\_Framework\_Eng.pdf

II. Regional Cooperation Plan on Building a Quality Living Area a) English, http://www.epd.gov.hk/epd/english/resources\_pub/publications/files/qla\_plan\_eng.pdf

b) Chinese, http://www.epd.gov.hk/epd/tc\_chi/resources\_pub/publications/files/qla\_plan\_chi.pdf

Accepted. The following revision was made:

1. Introduction, when discussing the reason Guangzhou is selected as an example, we added the following sentences:

“The successful regional cooperation between the governments in Guangdong and Hong Kong helps the understanding of the PM2.5 and ozone status, which are very much regional in nature. The regional collaborative efforts on joint air quality management includes establishing the first PRD regional air quality monitoring network since 2005 to provide high quality air pollution data and publishing data, which has been otherwise under tight scrutiny in the past. (reference: Zhong L., P. Louie, J. Zheng, K.M. Wai, J. Ho, Z. Yuan, A. Lau, D. Yue and Y. Zhou: The Pearl River Delta Regional Air Quality Monitoring Network – Regional Collaborative Efforts on Joint Air Quality Management, Aerosol and Air Quality Research, doi: 10.4209/aaqr.2012.10.0276)”

1. Section 3.1, control principal:

“The regional control is also considered in this research to provide a background emission inventory. To augment the analysis with local information, the following documents are referenced to develop the regional action plan. 1) before 2012: ‘Clean Air Action Plan in Pearl River Delta in Guangdong Province’, 2) from 2012 to 2020: the ‘Outline of the Plan for the Reform and Development of the Pearl River Delta (2008-2020)’, the ‘Regional Cooperation Plan on Building a Quality Living Area’, the ‘Jointly Prevention & Control of Regional Air Pollution in Pearl River Delta in Guangdong Province’, as well as the ‘Emission Reduction Plan for 2012~2020, Committed by the Framework Agreement between Guangdong and Hong Kong Governments’.”

1. Concluding Remarks:

“Regional cooperation efforts would help the evolution of industrial growth and emission control and provide an evidence-base air quality framework for regional air quality management.”

6. RE: page 20938, lines 15-21 and Table 1, Without taking into consideration of the difference in VOC composition, OH concentration levels, emission sources and individual species reactivity levels in terms of ozone formation, it may be too crude to make estimations for VOC/NOx reduction ratios by simply comparing the control efforts between PRD and California. The authors should at least acknowledge the limitations of taking this approach or the scientific basis of making this kind of estimations of VOC/NOx reductions ratio should be stated carefully. Nevertheless, putting VOC as one of the pollutants to be targeted for specific control is a correct direction. But more scientific studies in the PRD region to support the evaluation of control strategies and formulation of effective control strategies are needed.

Accepted. We have mentioned this limitation of taking this approach in the revision. Section 5.2, table 1:

“Both this study and the California VOCs emission data provide only total VOCs or ROG emission amounts without detailed species and ozone formation potential information. More scientific studies in the PRD region are needed to support the evaluation of control strategies and ozone effects. These studies must consider the difference in VOC composition, OH concentration levels, and individual species reactivity levels. Nevertheless, Guangzhou needs very strong control of VOCs to reduce its ozone.”

7. In terms of economic, China is on a significant growth path, how would the emission reduction targets account for the growth factor for all the major pollutant list in the paper (SO2, NO2, PM10, PM2.5, and VOC). In other words, are growth factors accounted for in model scenarios? If not, why not.

Yes, the economy growth is accounted in our scenarios. The logic is project non-control scenario considering economic development and then project emission reduction based on government plans. An additional description is provided in section 3.2:

“A Business As Usual (BAU) scenario is set up as the first step to reflect the projection of economic development in the region with the present emission control level maintained. If no further control is taken in Guangzhou, the total emissions of SO2, NOX, PM10, PM2.5, and VOC would reach 145, 361, 173, 84 and 402 thousand tons by 2025.

The major pollution control measures include:….

Based on those emission control plans, an estimate can be made of the changes on emission rates as well as source activity levels.…

Combined with our base year emission inventory, the emission reduction potential for both new sources and present sources were estimated using a bottom-up approach.”

8. RE: page 20935, under air quality models and model evaluation, the evaluation of compliance for PM2.5 and PM10 with the annual standards were performed, however, the evaluation for 24-hr standards were missing. Why the evaluation for 24-hr standards were missing?

The target of model use in this study is to provide the annual concentration because the first step on air quality improvement is based on annual concentration attainment. Thus, the evaluation of compliance for PM2.5 and PM10 with the annual standards was performed. To further provide a technical background to readers, we reference our previous paper to explain the model evaluation. In our previous research, the evaluation based on 24-hr concentration is provided.

We made the following changes in section 4.1 of manuscript:

“The target of model use in this study is to provide the annual concentration because the first step on air quality improvement is based on annual concentration attainment. Thus, the evaluation of compliance for PM2.5 and PM10 with the annual standards was performed.”

Technical corrections

1. I would recommend an English speaking to review and polish the paper with a view to add clarity and help the readers better understand the key issues.

Accepted.

1. Page 20925, line 22 “The annual health standard for PM2.5 was setting. . ...for the first”, this should be air quality standard rather than health standard.

Accepted.

1. Page 20929, line 19, “constant” should read “consistent”.

Accepted.

1. Page 20929, line 22, “The problem would be a local issue rather than a regional issue”. Any scientific basis to back up this claim? What is the share or ratios between local and regional contribution to PM10 levels in Guangzhou?

Accepted. We do not want to discuss the contribution to PM10 here, thus this sentence is deleted. By the way, this modification should be in Page 20929, line 27.

1. Page 20931, line 15, “. . .into secondary particulates such as sulfate and nitrite” should read”. . . into secondary particulates such as sulfate and nitrate”.

Accepted.

1. Page 20933, line 6, “. . .standards, e.g., Euro 5 standards for vehicles. . .”, not clear if Euro 5 and China national V standards are the same or not. For consistency sake, better stick to China national V standard.

China has not released China national V standard yet. Technically, there’s no China V standard. Thus, we keep using the phrase Euro 5 here.