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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Local and regional contributions to fine particulate matter in the 18 cities of Sichuan Basin, southwestern China" *by* Xue Qiao et al.

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Dear reviewer,

Thank you for the comments to help improve the quality of the paper. We have revised the manuscript to address your comments and a detailed response to each comment is provided in this file. The comments are in regular font and the responses are in blue.

General Comments: The manuscript presents a good example of using CMAQ model to study sources contribution of air pollutants, specifically fine particulate matter, in Sichuan basin, one of China's economic development zones. The authors carried out

modelling studies with updated photochemical mechanism and aerosol module. The modelling results are well-organized with clear conclusions, which provide potential policy guidance for Chinese government agencies in terms of measures in pollution control.

Two of the highlights are:

1,"All the above suggest that it would be more efficient to control the SIA (particularly SO42-) and its precursors than PPM in order to reduce the transport of air pollutants within and into the basin" in lines 293 – 295

2, "All the above suggest that joint effect (it should be joint measures in reviewer's mind) should be made by neighbor cities and provinces to reduce PM2.5 pollution for the entire SCB" in Line 314 and 315.

Maybe the author can also strengthen how much/little Sichuan or Chongqing governments can achieve by just reducing the pollution sources alone based on the modelling results. Overall, the manuscript deserves publication in ACP after handling reviewers' comments and making some minor revisions/corrections.

Response: Thanks for the suggestions and positive comments! In this study, we obtained the source contributions from different regions. In a coming paper, we simulated air quality of the Sichuan Basin (including Sichuan and Chongqing) under different emission reduction scenarios, which exactly shows the point here.

Specific Comments:

1, This paper is designed to be published in "Special Issue: Regional transport and transformation of air pollution in eastern China". Could the authors address the relevance of this manuscript to the special topic, since SCB is in not in eastern China? Air pollutants generated in eastern China can be transported to SCB, as the modelling results have shown, which could be used to elegantly linking two distinct areas.

Response: Yes, this submission was intended to show the contribution of eastern

China to the SCB. The results do show that air pollutants generated in central and eastern China can transport to the SCB and may have considerable contributions to PM2.5 concentrations for the cities located in the eastern and northern SCB. In the revised manuscript, we have added sentences to address the relevance of this manuscript to the special topic in the second paragraph of the introduction section. “In addition, east and central China, which are to the east of the SCB, have considerable contributions to PM2.5 for the SCB. For example, Ying (2014) predicted that central and east China had a combined contribution of 29.6% to the total mass of $NO3-$ and $SO42-$ for Chongqing in January 2009”.

2, There seems to be too much educational material in the second paragraph of the introduction section. The authors explained some other models that the current study did not use in long words. Although it is important to compare the advantage of CMAQ model to these models mentioned, it seems to be slightly distracting. On the other hand, Sichuan Basin is surrounded by mountains in all directions, as the authors have mentioned. There is little discussion or explanation about how the topography will prevent the transport of air pollutants between SCB and other areas. This may deserve some words in the manuscript as one of the reviewers has criticized the manuscript as “quite short”.

Response: Thanks for the suggestions. (1) We made the summary of source apportionment methods more concise in the introduction section (third paragraph). (2) We added sentences in the introduction and a new section 3.4 to discuss about the impacts of topography on air quality in the SCB. âĂć In the introduction, we mention: “They are the Qinghai-Tibetan Plateau (QTP), Yunnan-Guizhou Plateau (YGP), Wushan Mountains (WUM), and Dabashan Mountains (DBM) to the west, south, east, and north of the SCB, respectively. As a result of the basin topography, emissions released from the SCB tend to accumulate in the basin, causing severe air pollution” âĂć In section 3.4, we summarized the results from all figures and tables to show the impacts of topography.

3, The modeling study is for the period between November of 2014 to August 2015, which include two winter seasons and one summer season, in addition to one spring season. Can the authors address the following questions: a) Why this period? Is the length of period the longest that CMAQ model or the supercomputing resources can handle? b) Why the spring season was not discussed? Is there a lacking of spring data or the results in spring are not as interesting as summer and winter? c) Is statistical significance the same to include two winter seasons but only one summer season? How biased it could be when averaging the trend?

Response: The modeling period is winter (December 2014 to February 2015) and summer (June to August 2015). One of the major objectives of this study is to understand the extent of transport of air pollutant within the SCB and from outside SCB into SCB. Based on measurements at the national air quality stations in the SCB, PM2.5 concentrations are highest in the winter and lowest in summer. In addition, wind speed is highest and lowest in summer and winter, respectively. Spring is much more windy and wet compared to winter. Thus, we assumed that the transport of air pollutants within the SCB and from outside SCB into SCB might be least significant in winter and might be greatest in summer. However, the simulation results show that transport of PM2.5 and its precursors are also significant in winter. For example, Chengdu, which is located in the western SCB and is one of the largest cities in western China, has 37.2% of PM2.5 due to emissions from other cities in winter. Suining in central SCB has 75.3% of PM2.5 due to emissions from other cities in winter. Computing power is not a concern here. We have added some sentences to explain this in the introduction section.

4, Part (b) of Figure 1 seems to be very crowded. Can the font of these city names be smaller but still readable? Can the size of dots representing those cities with SCB corresponds to its population of economic activity? Can the dots representing cities outside of SCB or beyond of the discussion be limited to several large industrial cities? Disregard this comment if this figure is directly generated by CMAQ model and not

easy to achieve these visual advantages.

Response: This figure was generated by using GIS. We have revised the figure.

5, In the end of the first paragraph in the introduction section, the authors mentioned the average measured PM2.5 concentration is six times of WHO guideline. If there are available data, can the authors present the data of the national average or somewhere else (which is suitable to serve as a benchmark comparison parameter) so that readers can understand the relative magnitude of SCB to the whole country or another region?

Response: Thanks for the suggestions. In the revised manuscript, we have added a figure (Figure S1) to compare annual average PM2.5 concentrations between the SCB cities and other Chinese cities.

6, There are a lot of exceptions for Suining, can authors generally address the reason with slightly more details? Is it the least developed area or some other reasons?

Response: In the revised manuscript, we added few information to address this in section 3.3.1: "The low local contribution in Suining might be because it is less economically developed compared to other cities, except for Bazhong, Guangyuan, and Ya'an, as suggested by the 2015 gross domestic production (GDP; Table S1)". Table S1 was added in the supporting material.

7, Why there are no space separating multiple citations in the parenthesis throughout the manuscript?

Response: We have corrected this.

Technical corrections: 1, Part of line 34 of Abstract should be corrected to: . . .(SIA, including ammonium (NH4+), nitrate (NO3-), and Sulfate (SO42-)). . ., similarly, part of line 124 should be corrected to: . . . (SIA, including NH4+, NO3-, and SO42-). . ., there is no reason to explain only one of the three items/ions for the second time and do it incorrectly Authors are courteously reminded here that ammonia = NH3 and ammonium = NH4+. It is better not to challenge the long established chemical

nomenclature, as the authors seem to get it right in line 163.

Response: Sorry we missed the word "ions". We have corrected this throughout the manuscript.

2, The manuscript describe the resolution as 0.1 $\times$ 0.1âŮę . Is it more accurate to use it as 0.1âŮę $\times$ 0.1âŮę as used in the companion paper?

Response: Modified accordingly.

3, Line 50, recommend changing to ". . . but fewer studies have been conducted compared with other developed regions. . .." Or ". . .but insufficient studies have been conducted. . ."

Response: Thanks. We have revised this.

4, Line 53, recommend changing "16 other cities" to "16 less populated cities" or something similar.

Response: Done.

5, Line 185, please get rid of the first word "were" or change it to "that were", otherwise the whole sentence doesn't make sense in grammar.

Response: Done. Thanks.

6, Line 192, can "statistical measures" be replaced by "statistical metrics", as used in the companion paper?

Response: Done. Thanks.

7, Line 226, can authors define "city center"? Is it the most populated place in the city or the central point (modeling domain) of that city?

Response: In the beginning of section 3.2.1., we explained this. In the SCB, almost all the national air quality stations (NAQs) are located in the central urban areas of the 18 cities. For example, there are eight NAQs in the Chengdu, including seven located

in the central urban areas and one located in the background site. In this study, we average the coordinates of the NAQs in the central urban area of each city in order to analyze PM2.5 and its source contributions in the most populated region of each city.

8, Line 331, can authors specify “severe events”? Should it only mean sever air pollution events?

Response: We changed to “severe PM pollution events”.

9, Table 2, the width of the second and fifth columns, “Number of grid cells” can be optimized to read better. For example, it can be changed to “No. of grid cells” to make it fit the space better without sacrificing the unambiguity.

Response: Done. Thanks!

10, Table S2 and S3 do not fit to a letter paper after print out. Please check if this would be resolved automatically during publication.

Response: The orientation of the two pages were changed into landscape view, so the two tables can fit into a letter or A4 paper.

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