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Geoscientific Model Development Discussions

Interactive comment on "The air quality forecast of PM₁₀ in Beijing with Community Multi-scale Air Quality Modeling (CMAQ) system: emission and improvement" *by* Q. Wu et al.

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The authors thank the editor and the reviews for their encourage and the constructive and up to point comments. Our detailed replies to the referee comments are given below. The Latex and its PDF file is present here.

1 Reply to Referee #2

We thank the referee for the precious and constructive comments. Our detailed replies are given below.

1.1 Comment from Anonymous Referee 2

Received and published: 7 June 2014

This is a useful paper, attempting to improve MM5-SMOKE-CMAQ model performance in the forecast by using some numerical methods such as enhance the inner domain and update regional point and area source emission. This study could contribute to the model performance improvement but some concerns need to be noted, and I recommend some revision before publication. 1. Could the authors provide the model evaluation on the surrounding cities, eg. Tangshan, Baoding or Landfang, where more point sources have been added to improve the simulation. Actually, I know it is hard work to collect the observation in China, but that will help us to know the model performance in the surrounding areas. 2. Please add some comparisons before and after improving the source emission without expanding the domain to make sure the model performance due to the emissions updated. 3. The paper is well structured and in reasonable English. However, I suggest it is edited carefully for various grammatical and syntactic errors prior to publication.

1.2 Respond

Comment: This is a useful paper, attempting to improve MM5-SMOKE-CMAQ model performance in the forecast by using some numerical methods such as enhance the inner domain and update regional point and area source emission. This study could contribute to the model performance improvement but some

concerns need to be noted, and I recommend some revision before publication.

Reply: The authors thank the referee for the encourage and comments, the manuscript would been revised according to the comments.

Comment: 1. Could the authors provide the model evaluation on the surrounding cities, eg. Tangshan, Baoding or Landfang, where more point sources have been added to improve the simulation. Actually, I know it is hard work to collect the observation in China, but that will help us to know the model per- formance in the surrounding areas.

Reply: In the past month, the hourly concentration of PM10 in Baoding, Tangshan and Xianghe stations are collected to illustrate the model performance in Beijing's surrounding areas. The observation is from the Beijing-Tianjin-Hebei Atmospheric Environment Monitoring Network operated by the Institute of Atmospheric Physics, Chinese Academy of Sciences(), and coveres the air pollution episode menioned in our manuscript. The location of the three stations are shown in Figure 1: Baoding and Tangshan stations are locate at the urban of Baoding and Tangshan Municipality, and Xianghe station is located at one county of Langfang Municipality.

As described in the left figure of Fig.2 in the manuscript, the fouth domain(D4) in the forecast system just covers Beijing Municipality, that Baoding, Tangshan and Langfang station, is either outside or nearby the domain boundary. Therefore, the "New" expanded domain is used, which domain can cover Beijing and its surrounding municipality. The model results driven by the forecast emission in the "New" domain have been compared to the model results presented in the manuscript, which is driven by the updated point and area sources emssions in the "New" domain. With this set of comparison, we can get the model performance on Beijing's surrounding areas, and get the model improvement due to the emissions updated.

The scatter plots and quantile–quantile (Q–Q) plots are used to illustrate the model per-

Fig. 1. The location of Baoding, Tangshan and Xianghe stations are shown as "green tringle". They are all in the Beijing's surrounding areas, where more point sources have been added in this paper.

Table 1. Statistical measures for PM10 hourly concentration in Baoding, Tangshan and Xianghe stations. The "rEmis" is mark that the model results driven by the forecast emission and the "New" is mark the model results driven by the updated emissions.

	Baoding		Tangshan		Xianghe	
	rEmis	New	rEmis	New	rEmis	New
MB	-208.22	-182.95	-121.69	-111.52	-141.73	-103.68
ME	209.53	187.42	133.07	130.25	143.00	117.07
FAC2	16%	33%	38%	35%	23%	48%
NMSE	4.258	2.702	2.549	2.036	3.064	1.367

formance. The Q–Q plots are introduced by Chang et al.(2004) (), and used to compare the concentration distributions between the simulations and observations, with the Q–Q plots, the biases at low or high concentrations are quickly revealed, which is used in Wu et al.(2012)() for model evaluation.

As shown in Figure 2, the CMAQ model has obviously better model performance in Baoding and Xianghe station, and a little model improvement in Tangshan station: the pink simulated–observed points in Baoding and Xianghe stations are much closer to the red line "y=x" than the blue ones according the left scatter plots. With the Q–Q plots in Figure 2, we also can found that the CMAQ model has better performance in both the high and low concentration range, and get better distribution on PM10 hourly concentration in Baoding and Xianghe stations.

The mean bias(MB), mean error(ME), fraction of predictions within a factor of two of the observations(FAC2) and normalized mean square error(NMSE) are calculated and shown in Table 1. Consistent with the scatter plots and Q–Q plots, the statistical measures indicate the model performance improved obviously in Baoding and Xianghe stations, that their FAC2 increases from 16% and 23% to 33% and 48% respectively

BaodingJan2010.png

TangshanJan2010.png

XiangheJan2010.png

Fig. 2. The scatter plot and quantile-quantile (Q–Q) plots of the observed and simulated

while the NMSE decreases from 4.258 and 3.064 to 2.702 and 1.367.

As shown in the plots and statistical parameters, after the point and area sources emissions updated, the model performance improved obviously, especially in Baoding and Xianghe stations. But we also can found that even the model performance improved obviously in Beijing's surrounding areas, their model performance of PM10 hourly concentration is poorer than the Beijing's, which the FAC2 of the hourly concentration can reach to 74% in the "New" simulation in the manuscript, with the same updated emissions and domain. There may be two reasons: first, the emissions in the surrounding area maybe still underestimated, that the Q–Q plots show that the model underestimates in both high and low concentration range in the three surrounding stations. Second, the model domain may need to be expanded much bigger if we want to get much better model performance in the surrounding area, for example, if we want to get much better model performance in Baoding Municipality, may we need to expand the model domain to cover Baoding's surrounding areas, e.g. Shijiangzhuang Municipality. Both of the two reasons need to be more in-depth analysis in the future study.

In the end, because this manuscript is focus on the PM10 simulation in Beijing, the model performance in the surrounding areas mentioned above, including the station map, scatter plots, Q–Q plots and statistical parameter will be present in the supplement materials to support our manuscripts.

Comment: 2. Please add some comparisons before and after improving the source emission without expanding the domain to make sure the model performance due to the emissions updated.

Reply: Thank you for your comment. Based on the time series plot "Fig. 7" in the manuscript, we have added one model result and present in Figure 3 as marked "NewEmis+FDomain(CMAQ)", which result is driven by the updated emissions without expanding the model domain, used the model domain in the forecast system.

As shown in Figure 3, the "blue dashed" line is similar to the "green dashed" line, which is the model results in the forecast system. The peak of the PM10–API in the "blue dashed" line is about 105, just a little improved than the forecast system results("green dashed"). Compared the "blue" and "green" dashed lines, they used the same model domain but different emissions, the "blue dashed" used the updated emission. It illustrates that the emission updated only can improve the model performance a little without expanding the model domain.

Further more, based on Figure 3, we have added another model result and present in Figure 4 as marked "FEmis+NewDomain(CMAQ)", which result is driven by the forecast emission but in the "New" model domain, shown as "green solid" line in Figure 4. Compared the "green solid" line and the "blue solid" line, the two model results also used the same model doman but different emissions, the "blue solid" used updated emission while the "green solid" used the original forecast emission in the same "New" expanding model domain, we can found that the "blue solid" line has obviously better model performance than the "green solid" line, and the peak of the "blue solid" reaches to 180, much closer to the observed "red solid" line than the "green solid" line, which peak is about 140 as shown in Figure 4. It illustrates that the same emission updated can improve the model performance obviously than the original forecast emissions in the expanded model domain.

With the two group comparison("dashed" and "solid") mentioned aboved, we can found that effect of emission updated will be obvious in the suitable model domain, as the expanded model domain in our manuscript.

Figure 4 and the discussion will be present in the supplement materials to make sure the model performance due to the model domain setup and emission updated.

Comment: 3. The paper is well structured and in reasonable English. However, I suggest it is edited carefully for various grammatical and syntactic errors prior to publication.

Fig. 3. The time series of the averaged PM10-API in the NSAQ stations in Beijing urban area. The red solid line is the observation, the green dashed line is in the forecast system and the blue solid line is in the "New" simulation(the hindcast). The "added" blue dashed line is the model results driven by the updated emission without expanding the model domain.

Fig. 4. Same as Figure 3, the added green solid line is the model results driven by the forecast emission in the "New" expanded model domain.

Reply: Thank you for your comment. We will try our best to improve the English presentation, and check the grammatical and syntactic errors as possible as we can. More, the English copy-editing is required to help us to improve the English presentation.

References

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Chang J. C, Hanna S. R: Air quality model performance evaluation. Meteorol. Atmos. Phys., 87:167–196, 2004

Wu Q. Z., Wang, Z. F., Chen, H. S., Zhou W and Wenig M: An evaluation of air quality modeling over Pearl River Delta during November 2006, Meteorol Atmos Phys, 116:113–132, 2012.

Please also note the supplement to this comment:
http://www.geosci-model-dev-discuss.net/7/C1100/2014/gmdd-7-C1100-2014-supplement.pdf

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Interactive comment on Geosci. Model Dev. Discuss., 7, 3403, 2014.

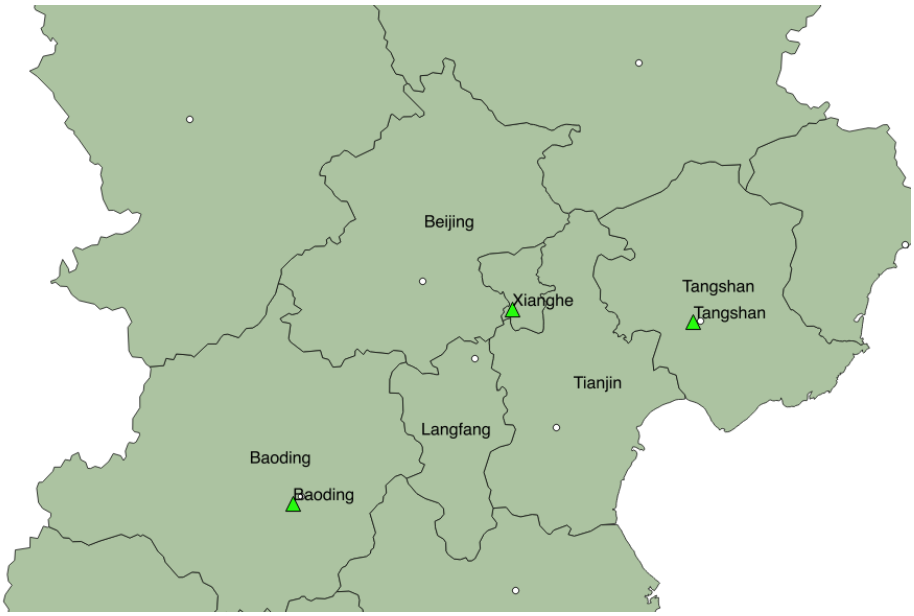

Fig. 5.

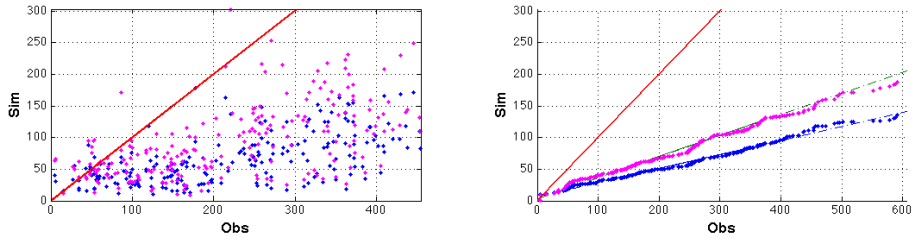
Sim
Obs
0
100
200
300
400
500
600
50
150
250

Fig. 6.

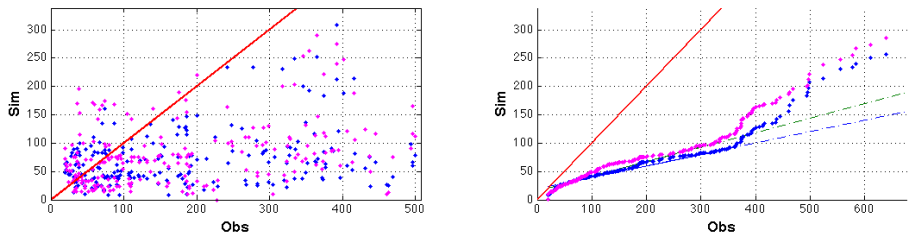
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Fig. 7.

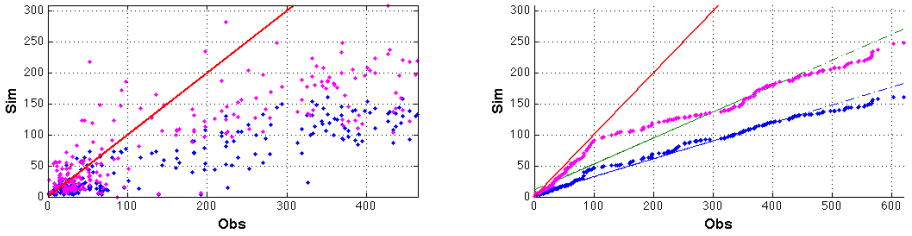

Sim
Obs
Sim
Obs

Fig. 8.

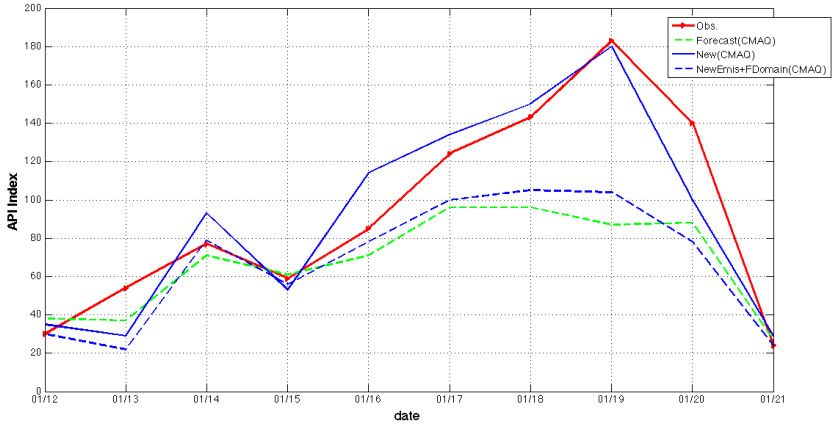
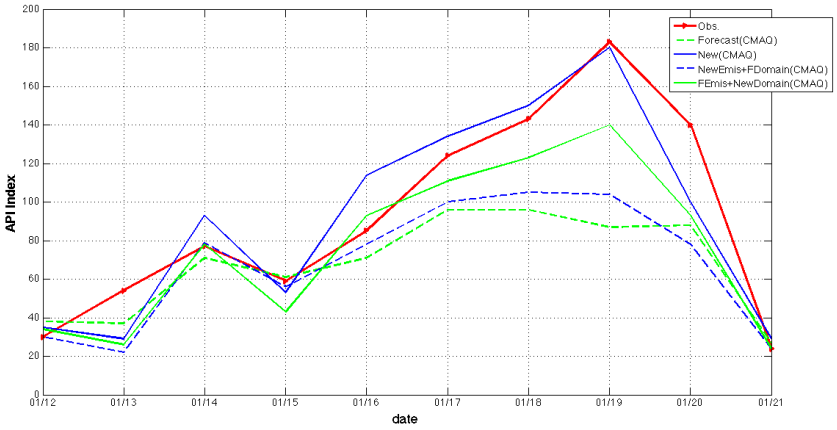

Obs.
Forecast(CMAQ)
New(CMAQ)
NewEmis+FDomain(CMAQ)
API Index
date

Fig. 9.


Obs.
Forecast(CMAQ)
New(CMAQ)
NewEmis+FDomain(CMAQ)
FEmis+NewDomain(CMAQ)
API Index
date
0
20
40
60
80
100
120
140
160
180
200
01/12
01/13
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01/16
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01/18
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01/20
01/21

Fig. 10.