Dear editor and referee#1,

Thank you very much for your time and attentions on this work. The comments and suggestions are very useful to improve our manuscript. Following is a point-by-point response to referee #1's comments. Texts in italic are the comments, those in black bold are our responses. We hope that you will find the changes satisfactory.

In this manuscript the authors updated the CUACE model with heterogenous reactions and updated dry deposition scheme of particles, and coupled it to the WRF model. This study also evaluated the WRF/CUACE v1.0 model by simulating $PM_{2.5}$*,* O_3*, and* NO_2 *concentrations in different seasons and different years. This article is clearly written and the methods are generally sound. I recommend the manuscript to be published unless the following comments are addressed:*

1. Line 234-235: The authors mentioned "The feedback of chemical species on meteorology in the current WRF/CUACE version is not realized". So in Figure 1, I suggest using dashed line to indicate the influence of chemical variables on WRF module.

Response: Thanks for pointing it out. It has been modified to dashed line in the revised manuscript.

2.Line 290-291: The simulations are relatively poor in the SCB, where the complex terrain poses great challenges to meteorological field simulations. Show the simulations results of the meteorological fields of the four regions in the supplementary, and compare the simulation results with in-situ observations.

Response: Following the suggestion, the simulations results of the meteorological fields of the four regions were added in the supplementary (as shown in Table R1). It can be seen that the simulations of meteorological fields in the SCB are relatively

poor than the other three regions. For example, the *R*, MB, NMB and RMSE values of T2 in the SCB are 0.88, 1.52 °C, 9.95 % and 2.50 °C, respectively, while the values in the other three regions vary from 0.91 to 0.93, 0.48 to 1.14 °C, 5.31 to 7.01 % and 2.01 to 2.39 °C. The *R* value of WS10 in the SCB is 0.40, which is obviously worse than that of the other three regions (ranging from 0.60 to 0.74), indicating the variation of WS10 in the SCB was not well reproduced by the model. We have added the comparison in Section 5.2 in the revised manuscript.

Table R1 Statistical metrics for hourly temperature at 2 m (T2), hourly relative humidity at 2 m (RH2) and hourly wind speed at 10 m (WS10), respectively in the NCP, YRD, PRD and SCB regions.

		Obs	Sim	*R*	MB	ME	NMB	RMSE
	T2 (°C)	17.31	18.07	0.91	0.76	1.87	7.01 %	2.34
NCP	RH2 (%)	62.88	51.10	0.80	-11.78	14.47	-18.94 %	17.91
	WS10 (m/s)	2.05	2.99	0.64	0.95	1.29	52.40 %	1.60
	T2 (°C)	17.29	17.77	0.93	0.48	1.62	6.34 %	2.01
YRD	RH2 (%)	70.74	64.51	0.82	-6.22	11.28	-8.55 %	13.95
	WS10 (m/s)	2.42	3.29	0.74	0.87	1.20	39.75 %	1.47
	T2 (°C)	22.92	24.06	0.91	1.14	2.06	5.31 %	2.39
PRD	RH2 (%)	75.74	67.20	0.78	-8.54	12.73	-10.72 %	14.88
	WS10 (m/s)	2.23	3.23	0.60	1.01	1.32	48.73 %	1.61
	T2 (°C)	18.02	19.53	0.88	1.52	2.04	9.95 %	2.50
SCB	RH2 (%)	74.17	59.87	0.73	-14.30	15.98	-19.00 %	18.77
	WS10 (m/s)	1.35	2.05	0.40	0.70	0.99	60.26 %	1.24

* All *R* (correlation coefficient) values passed $p < 0.001$.

* Obs and Sim represent the average observations and simulations, respectively.

3. In Section 5.3, the authors evaluated the model performance with and without heterogeneous chemical reactions during a haze event at the Langfang site. How about model improvements at the other sites in the YRD, PRD and SCB region?

Response: Sincere thanks for the suggestions. We have tried our best to collect observations of inorganic secondary aerosols in the three regions. So far, the observations from 3 to 29 December 2013 in Nanjing (located in the YRD) and from 1 to 10 January 2017 in Chengdu (located in the SCB) are obtained for evaluation (Fig. R1). As shown in Fig. R1, simulations of sulfate and nitrate in the two sites

are generally improved (change in bias from −95.3 % to -68.4 % in Nanjing and from -88.7 % to -80.1 % in Chengdu for sulfate; change in bias from 83.0 % to 54.6 % in Nanjing and from 67.6 % to 23.5 % in Chengdu for nitrate). The results were added in Section 5.3 in the revised manuscript. We will continue to collect data in the PRD for evaluation in future work.

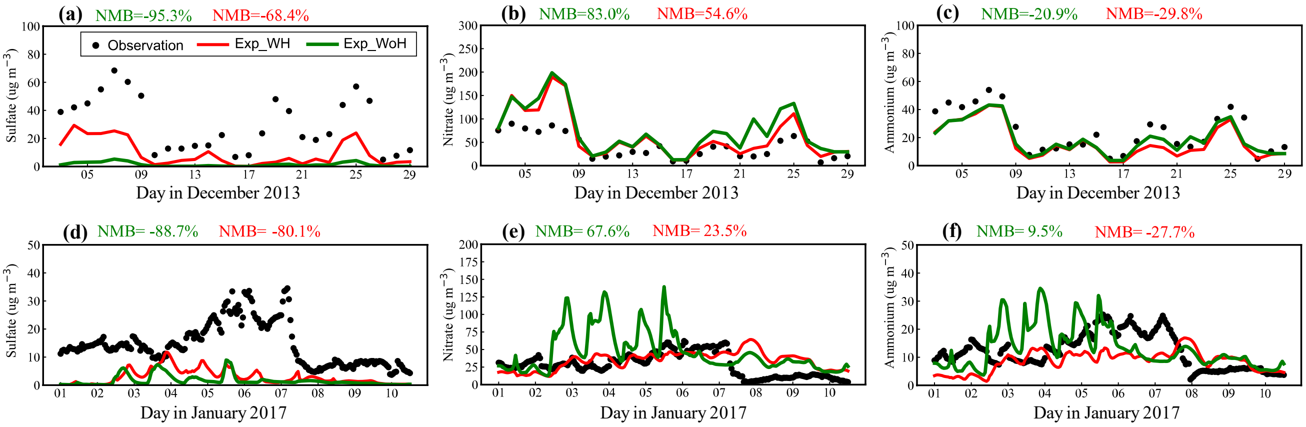

Figure R1. Observed and simulated hourly SIA concentrations from the Exp_WH and Exp_WoH experiments at the (a-c) Nanjing and (d-f) Chengdu site.

4. Line 90-91: This study also updated the dry deposition scheme of particles in CUACE. Please also show the model improvements with and without the updated dry deposition scheme in the supplementary.

Response: Thanks very much for the suggestions. We performed simulations for a winter month (January in 2015) to show the model improvements with and without the updated dry deposition scheme. As shown in Fig. R2, the $PM_{2.5}$ concentrations were commonly underestimated with the Z01 scheme (Fig. R2a), as it tends to overestimate the dry deposition velocity of fine particles (Petroff and Zhang, 2010). The underestimation was improved significantly when the Z01 scheme was updated to the PZ10 scheme (Fig. R2b). We have added the improvements in the supplementary.

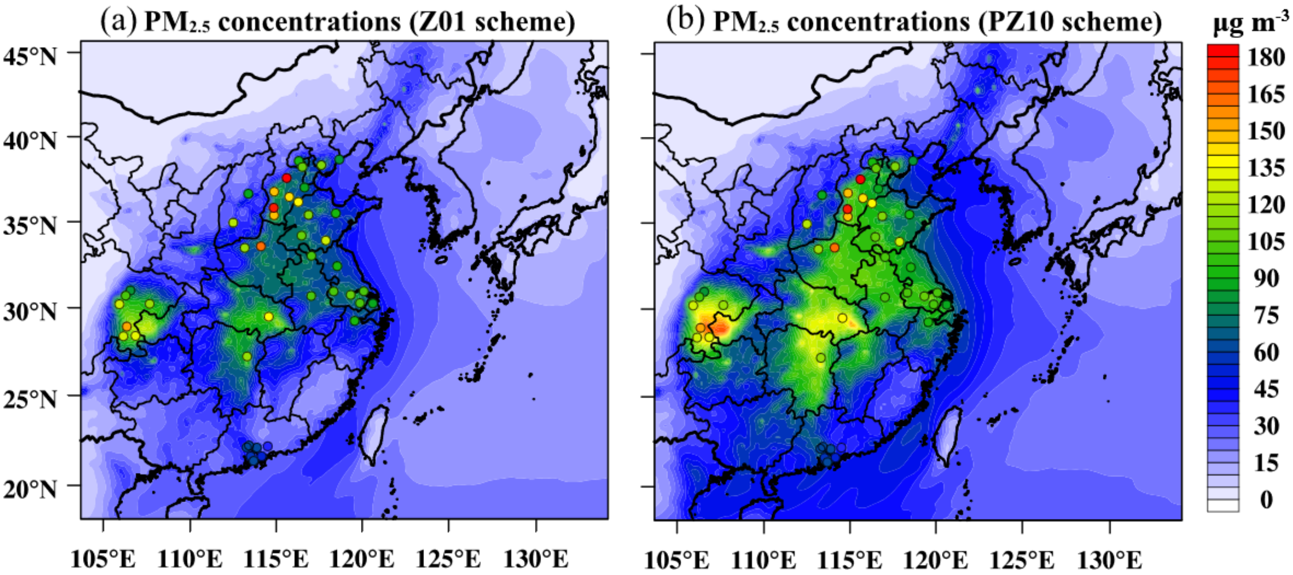

Figure R2. Observed and simulated $PM_{2.5}$ concentrations with (a) Z01 and (b) PZ10 particle dry deposition schemes.

Reference:

Petroff, A. and Zhang, L.: Development and validation of a size-resolved particle dry deposition scheme for application in aerosol transport models, Geoscientific Model Development, 3, 753-769, 2010.