Dear Anonymous Referees,

Thank you for your thorough review of the manuscript. We have read the editor's and the reviewer's comments carefully, taken all of reviewer's comments into consideration and revised the manuscript accordingly. All the changes have been highlighted in the revised manuscript. Our detailed responses, including a point-by-point response to the reviews and a list of all relevant changes, are as follows:

Responds to the comments from Anonymous Referee #3

Q: One of the major conclusions from this study is that the two-moment cloud scheme (WDM6) alone can be counter-productive, therefore, realistic aerosol information needs to be provided to capitalize on the strength of the newly introduced scheme in GRAPES/CUACE. Why is the predefined aerosol dataset not realistic, and how different is it from the "realistic" dataset provided by CUACE? Is this WDM6 previously parameterized for cleaner environment where the aerosol loading is considerably different from the study regions? Answers to these questions can be useful for modelers who want to apply such a scheme elsewhere.

A: This is a key question to the paper and also is the improvement point that this paper is trying to present. As we all know that cloud formation is closely related to the aerosol concentrations, especially to the number concentrations, which have a large spatial and temporal distribution in the atmosphere. The predefined aerosol values used in the previous two-moment cloud scheme (WDM6) had a constant value (1.0E8 m^{-3}) that did not change with time to reflect the real atmospheric concentrations.

From measurements, the aerosol number concentrations in east part of China are quite different from the predefined value. As it was showed in the **TABLE 1** from the paper (Shen, X. J, et al. Atmos. Chem. Phys., 11, 1565–1580, 2011, doi:10.5194/acp-11-1565-2011), the aerosol number concentration in urban area could reach 1.0E11 m^{-3}. Even in Waliguan, the global remote background site in Asia, the number concentration was in the order of 1.0E9. Measurements in the free troposphere and the PBL in Northern China Plain, one of the most polluted region in China, showed that the aerosol number concentration was in the order of 1.0E9 to 10E10 m^{-3} in clear days(Zhang Qiang, Atmos. Environ., 43 (2009) 5526–5535), indicating that aerosol number concentrations in east China are much higher than the predefined value in the original WDM6 which represents a much cleaner environment.

Table 1. Overview of experimentally determined particle number concentrations in the troposphere over China.

	Number concentration (cm^{-3})				Reference
Diameter range (nm)	3–20	20–100	100–1000	3–10 000	Wu et al. (2008)
Beijing, urban, 2 years	9000	15 900	7800	32 800	
Diameter range (nm)		10–100	100–500	10–500	Gao et al. (2007)
Jinan, urban					
summer, 12 days		10 300	385	10685	
winter, 18 days		15 591	1796	17387	
Diameter range (nm)		10–100	100–500	10–500	Gao et al. (2009)
Shanghai, suburban,		28 511	1676	30 187	
2 months					
Diameter range (nm)	3–20	20–100	100–1000	3–10 000	Yue et al. (2008)
Yufa, rural, 1 month	2000	9000	5000	17 000	
Diameter range (nm)				3–10 000	Liu et al. (2008)
Xinken, rural/coastal,1 month				16 300	
Diameter range (nm)	12–21	21–95	95–570	12–570	Kivekäs et al. (2009)
Waliguan, remote rural,	570	1060	430	2030	
22 months					
Diameter range (nm)	3–25	25–100	100–1000	3–10 000	This work
Shangdianzi, rural, 1.5 years	3610	4430	3470	11 510	

Therefore, the model produced aerosol concentrations for the two-moment cloud scheme with a more realistic spatial and temporal distributions and hence improve the aerosol-cloud interactions in the model.

Q:The reviewer noticed that the model performance for PM2.5 simulations by CUACE is not excellent yet, indicated by the low correlation coefficient and the fork-shaped distribution of data pairs in the scatter plot (Fig 8a). As the ACI plays different roles indifferent parts of the model domain, it is desirable to evaluate the model performance for different regions, especially in regions where the effect of ACI is significant. This new information is necessary to uphold the claim made in the manuscript as explained in the comment above.

A: Yes, it is quiet right that the PM simulation is vital important for the ACI in the modeling system. The PM concentration is affected by emission, meteorology and aerosol micro-physics and chemistry. Generally, the average ability for aerosol simulation is in a scale of a factor of 2 compared to measurements for most models. The performance of CUACE has been evaluated and reached that level (zhou, et al., 2012, Tellus B, 64, 18965).The mean concentrations are consistent with the observations.

The scattered plots of PM evaluation for the largest region R1which include regions 4 and 5 where the ACI is very significant and correlation coefficients for all the five regions have been presented in the paper. According to the reviewer's comment, The **scattered plots of PM evaluation for regions 4 and regions 5 have been added into Figure 8 and in line 486-491.**

Q: Specific comments: There are a number of formulas given but not all variables are explicitly denoted. Suggest a throughout checking of the manuscript on this matter.
A: Thanks. The missing donation of variables have been added in formula (1), (3) and (6) and highlighted in yellow.

Q: P15756: Line 17: spell out "TS" Throughout the text: remove initials of first names

incitations "R.H. Zhang et al".
A: There are 24 TS in the paper, all have been corrected into **threat Score, threat Scores or threat Scoring**.
Citations " R. H. Zhang et al" and citations "X. Y. Zhang" have all been corrected in the paper.

Q: P15764Eq 6, what is rco?
A: rco is the total condenses in the upper draft in the convective air mass. The explanation of rco has been added into the paper.

Q: P15771 Lines 11-13: How can one define "real aerosol size and number concentration"? Note the evaluation in the following section could not support this statement because neither size nor number concentration data are used to verify the model simulated aerosol information.
A: Thanks for the question. The **REAL** aerosol size and number concentrations means they are calculated from emission, transport and activated in GRAPES/CUACE, compared to the predefined concentrations. The sentence has been changed into "**Only the WDM6 with the aerosol size and number concentration information from CUACE driven by emission and the physics, as in T3, can significantly improve the model precipitation simulation ability.**" in line 443-446

Q:P15772:What is CAWNET? Need reference and more information about the observation.

A:Reference and more information have been explain in " The surface daily and hourly $PM_{2.5}$concentrations from CMA Atmosphere Watch Network(CAWNET) are used to evaluate the performance of aerosols (Zhang et al., 2008;Zhang et al., 2012a)." in line 289-291.

Responds to the comments from Anonymous Referee #4

Q:1.Introduction: The sentence "Hygroscopic aerosols can act as cloud condensation nuclei (CCN) or ice nuclei (IN)" should be revised as " Aerosols....", it is more general. Since cloud nucleation processes are sometime involved into a very complicated microphysical process, such as freezing nucleation, not only for "hygroscopic aerosols".
A: Yes, I agree. It is more reasonable without the word "Hygroscopic". The word of "Hygroscopic" has been deleted.

2. Introduction: authors should notice that WRF-CHEM model has same aerosol-cloud interaction scheme, which should be mentioned in this part. One of weak points is that WRF-CHEM uses a relatively rough emission scheme for regions in China, so authors also should clearly state what emission source is used in your model.
A:Yes, I agree. The emissions used in CUACE are the same emissions from Cao,2006 but the national official basic information of emission sources have been updated to the year of 2010.This information has also been added into the line 142-143.

3. Section 3.2 Numerical experiment designs: please give the horizontal resolution of simulation, which is important to simulation cloud and precipitation processes.

A: Thanks. The resolution of GRAPES/CUACE has been added as the following "The meteorological initial and boundary conditions, **at the resolution of 0.5 °**, are interpolated from the forecasting outputs of the CMA medium Meteorological model T639 in 6-hour interval." in line 287.