<u>Referee #2 Ghan</u> (Review comments in regular; **response in bold**.)
This manuscript presents a clear comparison between two very different models driven by the same boundary conditions but yielding very different results. The analysis clearly reveals the causes of the differences. The work has important implications for global estimates of aerosol effects on clouds.

Lines 29-30. The word "show" is used twice in this sentence. I suggest instead "Observations of ship tracks show that the liquid water path (LWP) in marine boundary-layer clouds can either increase or decrease with increasing aerosol particles : : :"
Answer: Done.

Page 3. It's worth describing the subgrid treatment of cloud microphysics in CAM5: size distribution and subgrid variability.
Answer: Done. We added following in the revised manuscript:
"*In-cloud cloud water variability within a GCM grid is considered and represented by an explicit gamma distribution based on observed cloud optical depth variability in marine boundary layer clouds. The subgrid in-cloud water mixing* (q_c'') *follows a gamma distribution* $P(q_c'') = \frac{q_c''^{\,\nu-1}\alpha^{\nu}}{\Gamma(\nu)} exp(-\alpha\, q_c'')$, *where* $\alpha = 1/q_c'$ *,* q_c' *is mean in-cloud mixing raito and* ν *is chosen to be 1 for simplicity in the model. This subgrid variability function is used to derive factors which can then be applied to calculate microphysical process rates using only the mean in-cloud mixing ratios*."

Page 4. Does the GCE also use saturation adjustment? How does the dependence of autoconversion on droplet number compare with the KK scheme?
Answer: The version of GCE used in this study also uses saturation adjustment. Water vapor above saturation is removed at the nucleation step.

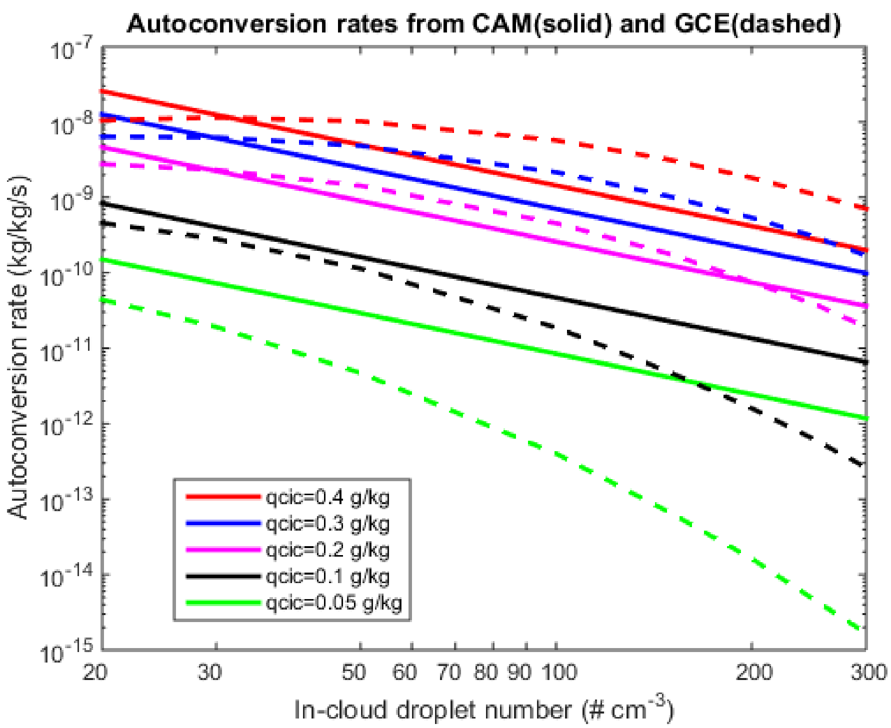

Figure 1. Autoconversion rates from Khairoutdinov and Kogan [2000] scheme used in CAM (solid curves) and stochastic collection equation solutions used in GCE (dashed curves) as a function of in-cloud cloud mass mixing ratio and number mixing ratio. An air density of 1.0 kg/m3 is used.

Figure 1 shows autoconversion rates from CAM's Khairoutdinov and Kogan [2000] scheme and the GCE. In both models, autoconversion rates are functions of in-cloud cloud mass mixing ratio (q_c) and number concentration (N_d). Compared to CAM's scheme, autoconversion rates from GCE are less sensitive to the change of N_d when N_d is less than 100 cm^{-3} and q_c is above 0.1 g/kg. When N_d is larger than 200 cm^{-3} and q_c is above 0.1 g/kg, the autoconversion rates from GCE have a larger dependence on N_d than CAM's scheme. The autoconversion rates from GCE also show larger dependence on the cloud mass mixing ratio as manifested by the wider vertical range of the curves.

Page 6, line 19. Start new paragraph here.
Answer: Done.

Page 6, line 30. Start new paragraph here.
Answer: Done.

Page 7, second paragraph. Please make clear which model is being discussed.
Answer: Done.

Page 8, lines 22-24. "This is likely due to the fact that the two models use different cloud droplet activation schemes as well as schemes to parameterize the autoconversion and accretion processes" Please demonstrate this with offline results.
Answer: Since aerosol number affects cloud droplet number and thus directly affects the autoconversion rate, we tested the response of autoconversion rate to increasing aerosol number in the two models. We extracted the two pairs of in-cloud droplet number/mass mixing ratios ([26 cm^{-3}, 0.167 g/kg] and [122 cm^{-3}, 0.293 g/kg]) from the center layer of clouds at the 11:30 hour from the two CAM cases in which the surface aerosol number increased from 250 cm^{-3} to 1000 cm^{-3}. The autoconversion rate from Khairoutdinov and Kogan [2000] scheme used in CAM decreases from 1.86e-9 to 4.67e-10 kg/kg/s. While applying GCE's scheme to these two pairs of data the autoconversion rate only decreases from 1.57e-9 to 1.48e-9 kg/kg/s. The two pairs of autoconversion rates are added to figure 1 to form a new figure 2 as showed below. We added this figure as Fig.S4 in the supplementary material.

We added following after the above referenced sentence:
"Since the autoconversion rate is directly affected by the aerosol number, we compared autoconversion rates from GCE and Khairoutdinov and Kogan [2000] scheme used in CAM offline. The results are shown in Fig. S4. Compared to CAM's scheme, autoconversion rates from GCE less sensitive to the number concentrations when the number concentrations are less than 100 cm^{-3} and the cloud mass mixing ratio is above 0.1 g kg^{-1}. When the cloud number concentrations are larger than 200 cm^{-3}, the autoconversion rates from GCE have a larger dependence on the number concentrations than the CAM scheme. However, they have a larger dependence on cloud mass mixing ratio than those from the CAM model. So increasing aerosol number tends to decrease the autoconversion rate more in CAM than in GCE. As an example, we extracted the two pairs of in-cloud droplet number concentrations and mass mixing ratios ([26 cm^{-3}, 0.167 g kg^{-1}] and [122 cm^{-3}, 0.293 g kg^{-1}]) from the center layer of clouds at the 11:30 hour from the two CAM cases in which the surface aerosol number increased from 250 cm^{-3} to 1000 cm^{-3}. When applying CAM's scheme to these two pairs of data, the autoconversion rate

decreases from 1.86×10^{-9} *to* 4.67×10^{-10} *kg kg*$^{-1}$ *s*$^{-1}$*. In GCE's scheme, the autoconversion rate only decreases from* 1.57×10^{-9} *to* 1.48×10^{-9} *kg kg*$^{-1}$ *s*$^{-1}$*. "*

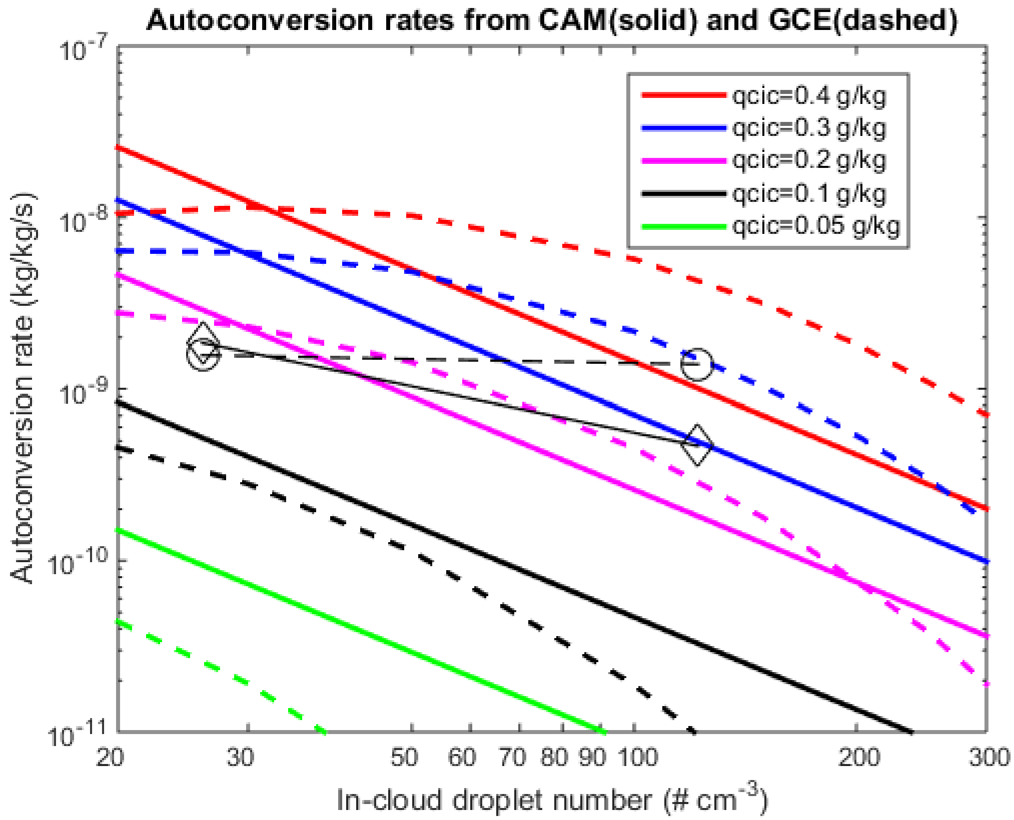

Figure 2. Same as Figure 1 except with 2 added pairs of autoconversion rates from Khairoutdinov and Kogan [2000] scheme used in CAM (diamond) and stochastic collection equation solutions used in GCE (circles). The two pairs of in-cloud droplet number/mass mixing ratio are [26 cm^{-3}, 0.167 g/kg] and [122 cm^{-3}, 0.293 g/kg] which are extracted from the center layer of clouds at the 11:30 hour from the two CAM cases with surface aerosol number of 250 cm^{-3} and 1000 cm^{-3} respectively.

Page 9, line 21. Insert "horizontal" before "grid".
Answer: Done.

Page 11, line 3. New paragraph.
Answer: Done.

Page 11, lines 10-13. I believe Chris Bretherton tried to implement a treatment of this mechanism in CAM but did not get the desired result. The code for that mechanism might even be in CAM5. I recommend contacting him about that.
Answer: We contacted with Chris Bretherton and cited the related work.