Comments on “Investigation of ice cloud modelling capabilities for the irregularly shaped Voronoi ice scattering models in climate simulations” by Li et al.

Anonymous Referee #1

General comments

I appreciate that the authors have provided reasonable responses to most of my comments. Please find follow-up comments below to improve the manuscript. However, there are still numerous errors throughout the manuscript. I even doubt if the authors did proofread it in response to my previous comment! In particular, a number of grammatical errors, inconsistent Table numbers, and inconsistent captions are found, which should be corrected. The topic presented in this study is suitable for Atmospheric Chemistry and Physics, and a minor revision is required for publication.

Response: Thank you very much for your significant comments.

Specific comments

1. Response to Comment #7: As the bulk mass extinction efficiency is a function of the bulk extinction efficiency, bulk geometric particle projected area and volume, and ice density. Since the geometric parameters do not change over spectral wavelengths, the bulk extinction efficiency should have a local minimum at the corresponding wavelength domain. The explanation that the authors have provided here makes physically no sense to me. If the minimum value of the real part of the ice refractive index leads to a minimum mass extinction coefficient, please provide the physical reason why it does.

Response: As you mentioned, we have analyzed the spectral features of extinction efficiency Q_{ext} of Voronoi ice particles. We choose six Voronoi ice particles with different effective diameters D_e and show their spectral Q_{ext} in Figure 1. As shown in Figure 1, we find that the Q_{ext} for all particles have a minimum near the λ equals

3 μm, which can lead to the minimum mass extinction coefficient $K_{ext}(\lambda)$ at the corresponding λ region according to Eq. (1).

$$K_{ext}(\lambda) = \frac{\int_{L_{min}}^{L_{max}} Q_{ext}(\lambda, L)A(L)n(L)dL}{\rho_{ice}\int_{L_{min}}^{L_{max}} V(L)n(L)dL} \quad (1)$$

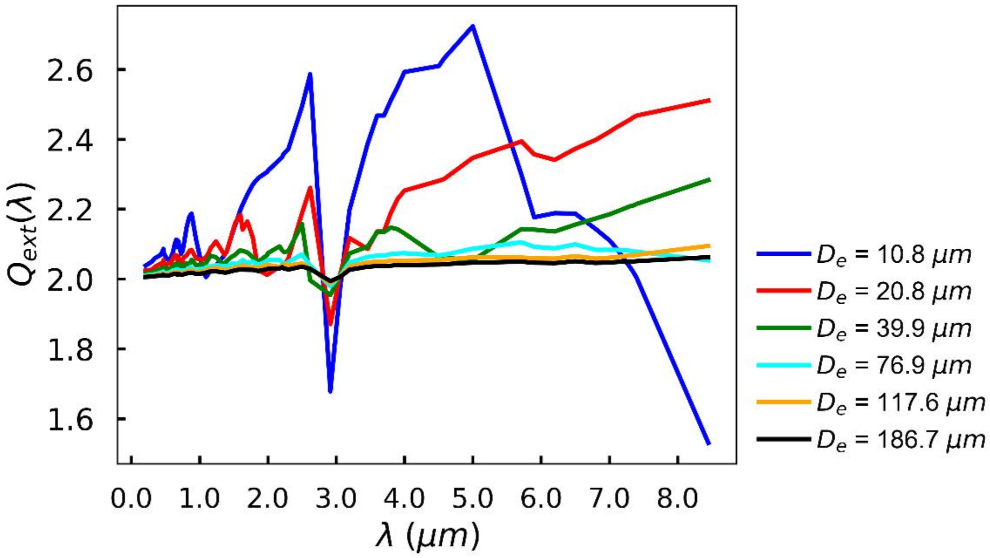

Figure 1. The spectral features of Voronoi ice particle $Q_{ext}(\lambda)$ for six particles with different D_e.

2. Response to Comment #16: If CAM5 unable to treat liquid and ice clouds individually, the present analysis may involve potential uncertainty associated with the ice/liquid fraction, which should be mentioned in the manuscript.

Response: According to the suggestions, we have added descriptions of potential uncertainty associated with the ice/liquid cloud fraction in section 4.3 as shown below.

Line 317-319 on Page 14: "Results show that the SWCF of CIESM simulations are stronger than the EBAF results in tropical regions. This might be because that the CIESM overestimates ice/liquid cloud fraction in low-latitudes compared with the observations (Eidhammer et al., 2014; Kay et al., 2016)."

3. Line 139 "The single-scattering albedo at both wavelengths is close to 1, which is related to the high values of the imaginary part in the refractive index.": High value of the imaginary part of the refractive index indicates very absorptive, and therefore SSA should be low.

Response: According to the suggestions, we have corrected this error as shown below.

Line 141 on Page 6: "The single-scattering albedo at both wavelengths is close to 1, which is related to the high values of the real part in the refractive index."

4. Line 159: "compared" should be "compare".

Response: As you mentioned, we have corrected the error in Line 161 on Page 7.

5. Line 228 "see Table 1": This should be Table 2, shouldn't be?

Response: Yes. As you mentioned, we have modified the error in Line 230 on Page 11.

6. Line 240 "The CIESM is run in two ways:" it has two verbs. It seems to me that a proofread was inadequate. Please double check the grammar in the manuscript.

Response**:** According to the suggestions, we have checked the manuscript, and we have rewritten the above sentence as shown below.

Line 242 on Page 11: "The CIESM is operated in two ways"

7. Captions in Figs. 4-5: Although the figures show spectral bulk optical properties between 0.2-15 μm, the captions indicate the 14 shortwave bands, which is inconsistent.

Response**:** As you mentioned, we have corrected captions in Figure 4 and 5.

8. Lines 269 – 271: Why the Voronoi model has larger mass extinction coefficients than Fu, Yi, and Baum-yang05 model counterparts?

Response**:** According to the above Eq. (1), this is related with the extinction efficiency, projected area, and volume for ice particles. We don't have access to the single-scattering properties of ice particle habits utilized in the Fu, Yi, and Baum-yang05 schemes. So, it is difficult for us to quantify the differences in extinction properties among different ice particle habits.

Further, the Figure 6 in the manuscript displays that the Voronoi model has lower downward fluxes than Fu, Yi, and Baum-yang05 schemes. The extinction coefficient determines the cloud optical thickness and directly reduces the downward fluxes. The larger the extinction coefficient, the lower the downward fluxes. Thus, the results in Figure 6 are consistent with the conclusion that the Voronoi model has larger mass extinction coefficients than Fu, Yi, and Baum-yang05 schemes.

Reference:

Eidhammer, T., Morrison, H., Bansemer, A., Gettelman, A., and Heymsfield, A.: Comparison of ice particle characteristics simulated by the Community Atmosphere Model (CAM5) with in-situ observations, Atmospheric Chemistry and Physics Discussions, 14, 10.5194/acpd-14-7637-2014, 2014.

Kay, J., Bourdages, L., Miller, N., Morrison, A., Yettella, V., Chepfer, H., and Eaton, B.: Evaluating and improving cloud phase in the Community Atmosphere Model version 5 using spaceborne lidar observations, Journal of Geophysical Research: Atmospheres, 121, 10.1002/2015JD024699, 2016.