Zhang et al. investigate the impact of the shape parameter of cloud ice on simulated cloud properties and radiation using Community Atmosphere Model Version 6 (CAM6) of Community Earth System Model Version 2. The shape parameter is one of three parameters of the gamma distribution, which is commonly used in the two-moment bulk cloud microphysics scheme. Considering the current microphysics schemes usually set shape parameter to 0, investigate the impact of different values of shape parameter on the cloud properties providing important findings relevant to a GMD readership.

The authors conducted offline analysis and 10-year simulation using different value (0-5) of the shape parameter, in order to show how the shape parameter influences the cloud properties and radiation transfer. The authors suggested that increasing the value of the shape parameter would lead to higher qi and lower Ni in most regions globally, furthermore, the longwave cloud radiative forcing increases by 5.58 W m^{-2} (25.11%), and the convective precipitation rate decreases by −0.12 mm day^{-1} (7.64%).

After serious consideration, I here recommend this manuscript subject to major revisions

My major concerns are as below:

1. If I understand correctly, the authors only added the shape parameter to the PSD of cloud ice, the PSD of snow is not considered. This should be indicated in the manuscript, because "ice crystal" represents all the ice particles (cloud ice and snow togther).
2. Observation data of ice water path (IWP), shortwave cloud forcing (SWCF), and longwave cloud forcing (LWCF) are need in Figure 4, Table 4, and related analysis. This will give important information of which value of shape parameter give more realistic simulation results compared with observation.
3. From Figure 4, the IWP, LWCF, and SWCF have dramatic changes over the tropics, with much smaller changes in the mid-and high latitude. As we know most of the cloud and precipitation process over the tropics is governed by the convection scheme.

Since the shape parameter is only introduced in the large-scale microphysics, while the convection scheme is not changed. Why do the IWP, precipitation, and cloud forcing have the largest change over the tropics? The reader may expect that the largest change is notiecd in the mid-and high latitude, where larger-scale microphysics treated most of the cloud process, therefore, your modifications should have a larger impact over there. Considering the convection precipitation changed also largely, this may indicate the change of IWP, precipitation, and cloud forcing is directly caused by the convection process (as a result of changed climate state), not by the shape parameter in the microphysics scheme.

Minor comments:

1. Line 22: “cloud-related process”, to be consistent with the beginning and ending of the sentence, better to use “cloud microphysical processes”
2. Line 24: “atmospheric models”, may be better to use the “global climate model” instead since some ideal model could describe the evolution of each cloud particle.
3. Line 26: “From the outset, the development of cloud microphysics schemes has resulted in two distinct categories: bulk microphysics parameterization and spectral (bin) microphysics”

   The recently developed Lagrangian particle-based scheme is another type.
4. Line 28: “The spectral (bin) approach represents” added explicitly before represents
5. Line 33: “In climate models with bulk cloud microphysics scheme,”

   may change to “In bulk cloud microphysics schemes of climate models”
6. Line 65: “number density” actually, it is number mixing ratio
7. Line 67: “number concentration” →number mixing ratio
8. Line 127: “30 vertical layers”, the default model setting is 32 layers, did you reset it to 30 layers?

9. Line 135: “the PSD of ICs and μi-related cloud microphysical processes are first illustrated by off-line tests.”

   PSD is illustrated by off-line tests looks wired, may try: “the impacts of μ on …. are investigate using off-line test”
10. Line 139: “Fig. 1 shows the impact of μi on the PSDs.” --> Fig. 1 shows the impact of μ on the normalized PSD of cloud ice.
11. Line 141-144: using normalized PSD instead of PSD for accuracy.
12. Line 143: “in terms of number” is it number fraction or number?
13. Line 145: “large IC scenario” large size or mass?
14. Line 191: “climate equilibrium states.” We usually use “equilibrium climate states”.
15. Line 194: “cloud microphysical process during one model time step.” Looks weird, is it process rate?
16. Line 211: “in the tropopause region, where homogeneous freezing produces a large number of ICs (not shown) due to sufficient soluble aerosol particles,” in the tropics, is a large number of ICs from convection detrainment and homogeneous freezing of cloud droplet or from “sufficient soluble aerosol particles”?
17. Line 355: “increases atmospheric stability via the radiative budget and then leads to weaker convective precipitation” How? could the author give a more detailed explanation?

Technical Comments:

1. Line 9-12: “The calculating formulas of statistical 10 mean radii indicate that, under the same mass (qi) and number (Ni) of ice crystals, the ratios of the mass-weighted radius (Rqi, not related to μi) to other statistical mean radii (e.g., effective radiative radius) are completely determined by μi.”

   This sentence is too long, separating it into two or three sentences.
2. Line 22: “cloud-related process”, to be consistent with the beginning and ending of

the sentence, better to use “cloud microphysical processes”

3. Eq. (1), (2), (3)… according to GMD publication format, a comma should be added after equations.
4. Separate Fig. 1 and Fig. 3 into two Figures, currently they are too small.