Reply to Anonymous Referee #1

We thank the reviewer for the careful reading of the manuscript and helpful comments. We have revised the manuscript following the suggestion, as described below.

This study uses a cloud-resolving model with an aerosol-aware cloud microphysics to investigate the convective cloud responses to aerosol perturbations over the Tibetan Plateau (TP). Considering the special topographic and meteorological conditions over TP, this study really extends the current aerosol-cloud interaction (ACI) research into a new regime on the earth. It is also interesting to see the comparison of the ACI between TP and the North China Plain for the similar type of cloud. The sensitivity experiments by perturbing the initial cloud convective strength demonstrate the simulated cloud and precipitation responses are robust. I have some minor comments for authors to address before I can recommend accepting this paper.

1 Comment: Both CCN and IN effects are considered in the CR-WRF cloud microphysics. Can authors distinguish those two effects on the mixed-phase clouds simulated in this study?

Response: We have clarified in Section 4: "*In the present study, both CCN and IN effects are considered in the cloud simulations. However, there are still difficulties in quantitatively distinguish those two effects on the ice-phase cloud development using sensitivity studies. Obviously, the CCN plays a dominant role in the mixed-phase cloud development. Even when the IN is scare in the atmosphere, the mixed-phase cloud development is not hindered with sufficient CCN, because freezing of raindrops, the subsequent splinter-riming process, and homogeneous freezing of cloud droplets still initialize the glaciation process to facilitate the development of the mixed phase cloud.*"

2 Comment: It is a little surprising to see the so good monotonicity in the responses of water content and precipitation to aerosols. Lots of studies have reported the reduced LWP by increasing aerosols under relative dry conditions. What is the ambient humidity in the simulations? How to treat moisture sources in the initial and boundary conditions? I would assume the water vapor amount can be limited over TP.

Response: We have clarified in Section 3: "*The water content and precipitation in the Cu-TP response well monotonically to the changes in the [Na]. Numerous studies have shown that the* *reduced liquid water path (LWP) by increasing aerosols under relatively dry conditions (e.g., Khain et al., 2005). During the summer monsoon season, the atmosphere over TP is humid due to the water vapor transport by the monsoon (Figure 1a). The ambient humidity in the simulations of the Cu-TP exceeds 80% in the low-level atmosphere, causing the good monotonicity in the responses of water content and precipitation to aerosols.*". We have also clarified in Section 2: "*The initial and boundary conditions of water vapor are from the sounding data. The simulations use the open boundary conditions under which variables of all horizontal gradients are zero at the lateral boundary.*".

3 Comment: In Figure 4, please plot where is the surface level and where is the freezing level (0 degree isotherm). Those are very important information, as your later explanation of the differences of aerosol effects between TP and NCP relies on them. With the lower freezing level at TP, does it also mean less liquid water content and less room for aerosol invigoration effect?

Response: We have modified Figure 4 as suggested. The lower freezing level generally reduces the liquid water content but causes early occurrence of the glaciation process, enhancing the aerosol invigoration effect.

4 Comment: L258, how does aerosol increase raindrop size and then foster freezing efficiency? I would think the other way, i.e., aerosols invigorate the convection, produce larger graupel, and then the melting of the graupel gives you larger raindrop.

Response: We have clarified in Section 3: "*In addition, increasing the [Na] invigorates the convection and produce larger graupels, and then the melting of the graupel causes the formation of larger raindrops (Table 1).*"

5 Comment: Table 1, the initial formation times of hydrometeors are not fully discussed. Why ice crystal formations time is shortened by aerosols in TP but prolonged in NCP?

Response: We have clarified in Section 3: "*The 0°C isotherm is at the level of around 5 km a.s.l. for the Cu-TP and Cu-NCP. However, the occurrence heights for the Cu-TP and Cu-NCP are more than 4 km and about 0.2 km a.s.l, respectively, and when an air parcel perturbed in the boundary layer ascends to form a cloud, the rising distance to the 0°C isotherm is about 1* *km over the TP and around 4 km over the NCP. Therefore, the ice crystal formation time is significantly shortened in the Cu-TP compared to the Cu-NCP.*"

6 Comment: For the aerosol concentrations shown in each plot, do they represent all types of aerosols in all size modes? How about using CCN concentration at 0.1% SS instead?

Response: We have clarified in Section 2: "*The sulfate, nitrate, ammonium, black carbon, organic, and dust-like aerosols in the accumulation mode are included to consider the aerosol CCN and IN effects. Therefore, the surface-level aerosol number concentration ([Na]) is used to represent all types of aerosols, and the CCN concentration at a certain supersaturation (SS) is not used in the study.*"

7 Comment: As the clouds in this study are precipitating, it is better called them cumulonimbus, rather than cumulus.

Response: We have changed "cumulus" to "cumulonimbus" when precipitation occurs in clouds.