We appreciate the suggestion from the referee. Reviewer reports are marked in black font, our responses are marked in black bold font, and the changes to the revised manuscript are marked in blue bold font.

This research incorporates a bin method into a bulk microphysical scheme (WDM) to calculate the warm rain process and uses this scheme to investigate the warm rain seeding effect through several sensitivity experiments. I suggest that the authors should provide more information about this new scheme.

We greatly appreciate the care taken by the reviewer in evaluating the manuscript. We believe the actions we have taken to address the comments have substantially strengthened the revision of the manuscript. Our bolded responses appear below the reviewer comments.

1. Line 65: "The WRF model employs … the third-order Runger-Kutta numerical method for solving the time split integration of the governing equation". In fact, the third Ruger-Kutta method is just an option in the namelist. input, you can also choose the fifth-order one, so it is not "The WRF model employs", but you choose this third-order method. Please reword.

   Response: We followed reviewer's suggestions to revise the manuscript. The sentence on Line 65 changes to

   "The WRF model employs an eta coordinate, which allows the grids to follow the complex terrain, and we apply the third-order Runge–Kutta numerical method for solving the time split integration of the governing equation".

2. Line 98: "the bins of CCNs whose size extends the critical radius will be able to activate the corresponding liquid bins", How to understand "corresponding liquid bins"? I feel that the WDM-NCU scheme has not been introduced in detail in this manuscript. What is the size range of the 43 bins? Which microphysics processes are calculated in this bin scheme? Can this scheme reflect the fact that large CCN becomes large cloud droplets? How does the scheme deal with the coupling of the bin part and bulk part?

   Response: In WDM6-NCU, there are 43 mass-doubling aerosol bins, the radius ranging from 0.001 to 20 μm, and 43 mass-doubling liquid bins, the radius ranging from 2 to 32700 μm. After evaluating the critical radius based on Köhler theory, CCNs with the size extending critical radius will be activated to the five times CCN radius liquid bins (Lee and Baik, 2018). Activation process would be parameterized by evaluating the number concentration and mixing ratio of CCN extending the critical radius. Therefore, this scheme can reflect the fact that large CCN becomes large cloud droplets, and the activation process can contribute to the number concentration and mixing ratio of cloud and rain to couple the bin part to the bulk part. We add the detail information and the schematic of WDM-NCU in the revised manuscript (Lines 92, 99, 105-107, Fig. 2).

   Line 92: "… the seeded CCNs are described using mass-doubling aerosol bins of 43 sizes, the radius ranging from 0.001 to 20 μm, to evaluate the effects of CCN."

Line 99: "… the bins of CCNs whose size extends the critical radius will be able to activate the corresponding five times CCN radius liquid bins, the radius ranging from 2 to 32700 μm (Lee and Baik, 2018)."

Line 105-107: "The schematic of WDM6–NCU is shown in Fig. 2. Therefore, this scheme can reflect the fact that large CCN becomes large cloud droplets, and the activation process can contribute to the number concentration and mixing ratio of cloud and rain to couple the bin part to the bulk part."

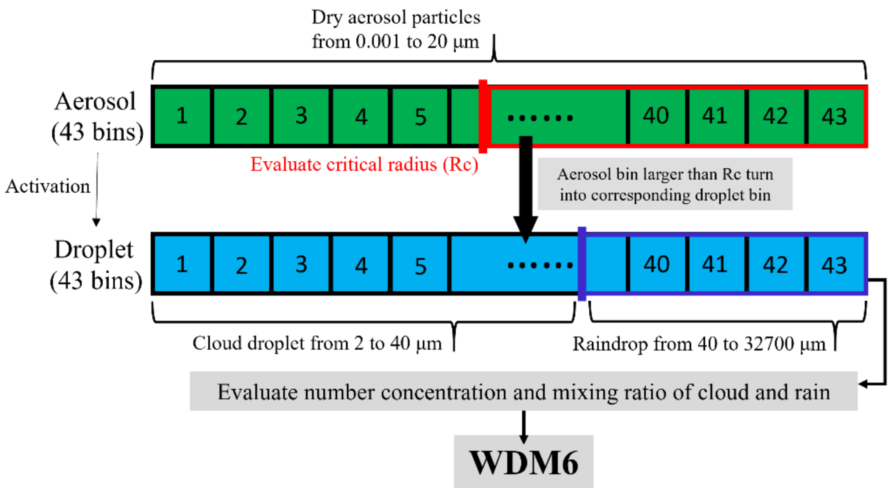

Figure 2: The schematic of WDM6-NCU.

3. Line 102: "After the number concentration and mixing ratio of the liquid bins is calculated, they are used in the calculation of the mixing ratio and number concentration of cloud and rain, and the microphysics processes continue as the case in the original WDM6". Do you mean that the bin part of the WDM-NCU scheme only calculates the nucleation process? How do you separate the cloud and rain categories from the liquid bins? The authors have to provide more information.

   Response: WDM6-NCU aims to improve the activation process to evaluate the cloud-seeding effects more accurately. Thus, the bin part evaluates the activation process and couple with the other microphysics processes in bulk part. We use the criterion of 40 μm to separate clouds and rain droplets in the liquid bins, and this information is added in the revised manuscript (Line 104).

   Line 104: "After the number concentration and mixing ratio of the liquid bins are calculated, they are used in the calculation of the mixing ratio and number concentration of cloud (radius ≤ 40 μm) and rain (radius > 40μm), …"

4. Fig. 5 The simulated accumulated precipitation comes from which domain? Is the horizontal space resolution close to the observed data?

   Response: Fig. 5 results come from domain four. The rain gauge data was interpolated to the same resolution as the model simulation. We add the information of accumulative data in the illustration of Fig. 6 in the revised manuscript.

The illustration of Fig. 6: "Figure 6: Cumulative rainfall based on (a) rain gauge observation data and (b) model simulation (D04) from 21 October, 2020 12:00 UTC to 22 October, 2020 12:00 UTC. Observation data is interpolated to the same resolution as the model simulation."

5. Fig. 6 What is RCWF and RCSL? They have not been explained in the manuscript. And which are observed data and which are simulated results?

   Response: RCWF is the S-band radar at WuFen Mountain, and RCSL is the C-band radar at ShuLin. Fig. 6 shows the observed data, proving the rainfall system mainly involves warm rain processes. The model simulation also captures this feature in Fig. 8. We add the information of two radars in the illustration of Fig. 7 in the revised manuscript.

   The illustration of Fig. 7: "Figure 7: RCWF, the S-band radar at WuFen Mountain, and RCSL, the C-band radar at ShuLin, radar reflectivity at different altitudes (1.5, 2, 3, and 5 km) and different times (06:30, 07:00, 07:30, and 08:00 UTC)."

6. Fig. 7, I suggest to depict the simulated results using dashed lines and put them over the observed data. So that only three 3 subplots are needed. And the Dongyan Mountain site should be plotted in Fig. 3 (or 5, 6).

   Response: We followed reviewer's suggestions to revise the manuscript. We plot simulation data as dashed lines and observation data as solid lines in the revised manuscript (Fig. 8). The location of Dongyan mountain site is also plotted in the revised manuscript (Fig. 4).

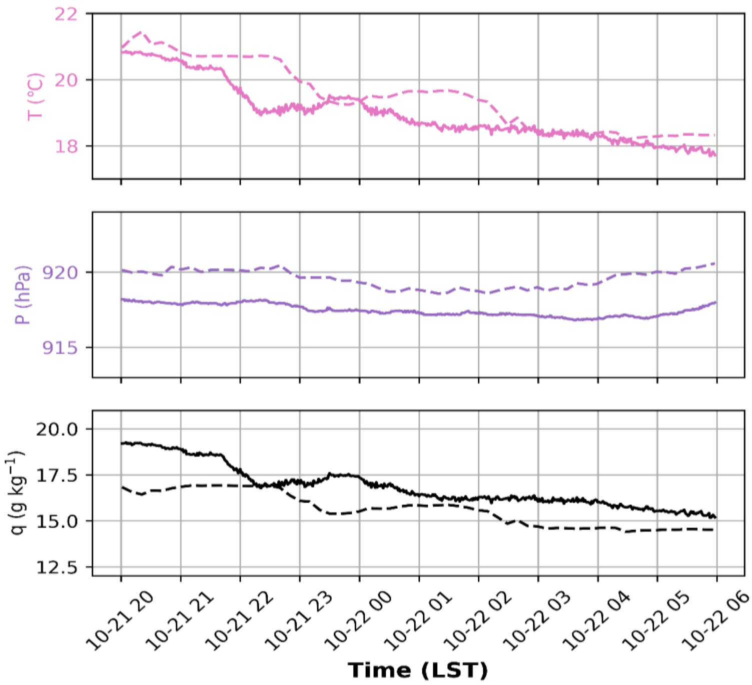

Figure 8: Time series (LST) of temperature, pressure, and water vapour mixing ratio based on observation (solid lines) and model simulation (dashed lines) in the Dongyan mountain site before cloud seeding was conducted.

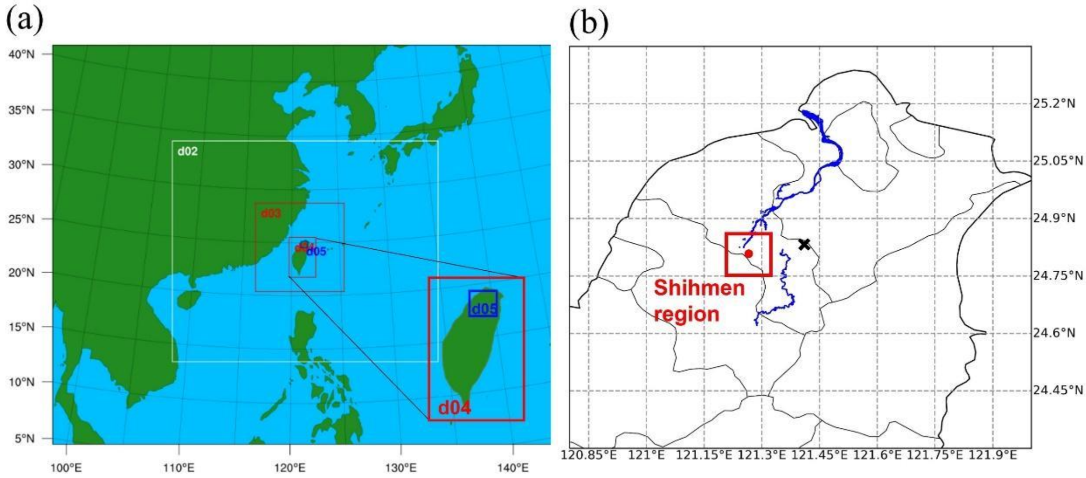

Figure 4: (a) setting of the nested domain and construction of five nested domains. (b) location of the Shihmen region. The red rectangle in (b) represents the Shihmen region, and the rivers shown on the map are Dahan river and Danshui river. The black marker X presents the location of the Dongyan Mountain site.

7. Fig. 8: Observation or simulation?

   Response: Fig. 8 is the simulation result. We add the description in Line 190 and the illustration of Fig. 9 in the revised manuscript.

   Line 190: "Figure 9 presents the meridional mean (0.1° latitude across Shihmen) of liquid water content (LWC) of model simulation at 06:30 UTC on 22 October, 2020."

   The illustration of Fig. 9: Figure 9: Meridional mean (0.1˚ of latitude crosses the Shihmen region) of liquid water content (LWC) of model simulation at 06:30 UTC on 22 October 2020. The black dashed line indicates the longitude of the Shihmen region, and the black line presents the altitude of 5 ˚C.

8. Where are the seeding points or areas when you seed in 1km^2, 10km^2, and 100km^2? These seeding points should be plotted. The seeding effects should also be shown in horizontal shadow figures, not just be plotted in lines as in Figs 9 and 10. And how much sea salt is seeded?

   Response: We followed reviewer's suggestions to revise the manuscript. The seeding areas are centered on 24.81˚N 121.26˚E, plotted as a red dot in Fig. 4 of the revised manuscript. The seeding effect on surface rainfall is plotted as shadow figures in Fig. 10a and 11a of the revised manuscript. The normal seeding rate is 2.03×10^4 (# cm^{-3} s^{-1}) based on the observation. The seeding rate is added in the revised manuscript (Line 155).

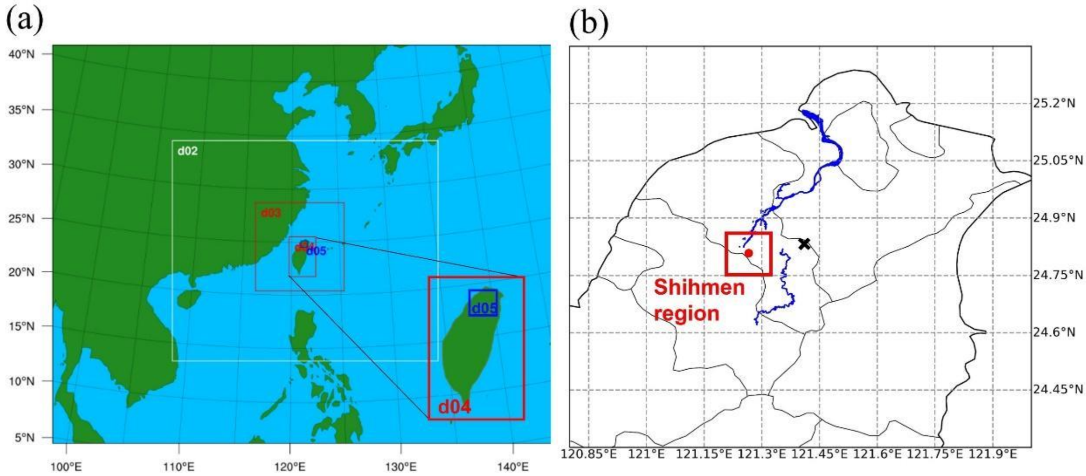

Figure 4: (a) setting of the nested domain and construction of five nested domains. (b) location of the Shihmen region. The red rectangle in (b) represents the Shihmen region, and the rivers shown on the map are Dahan river and Danshui river. The black marker X presents the location of the Dongyan Mountain site.

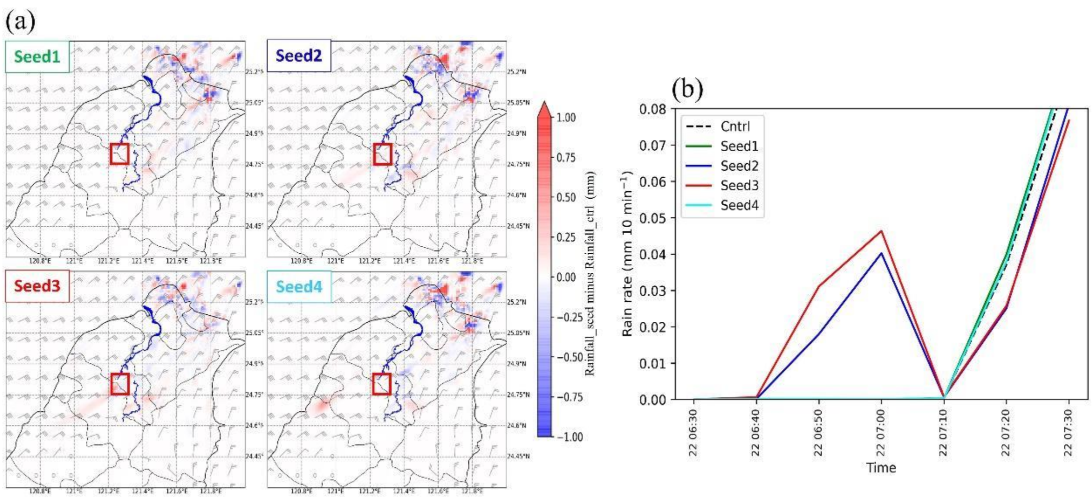

Figure 10: (a) 1 hr rain rate variation after cloud seeding (b) Time series (UTC) of averaged rain rate of the rainy grids in the Shihmen region for seed runs and the control run. The red rectangle in (a) represents the Shihmen region, and the rivers shown on the map are Dahan river and Danshui river.

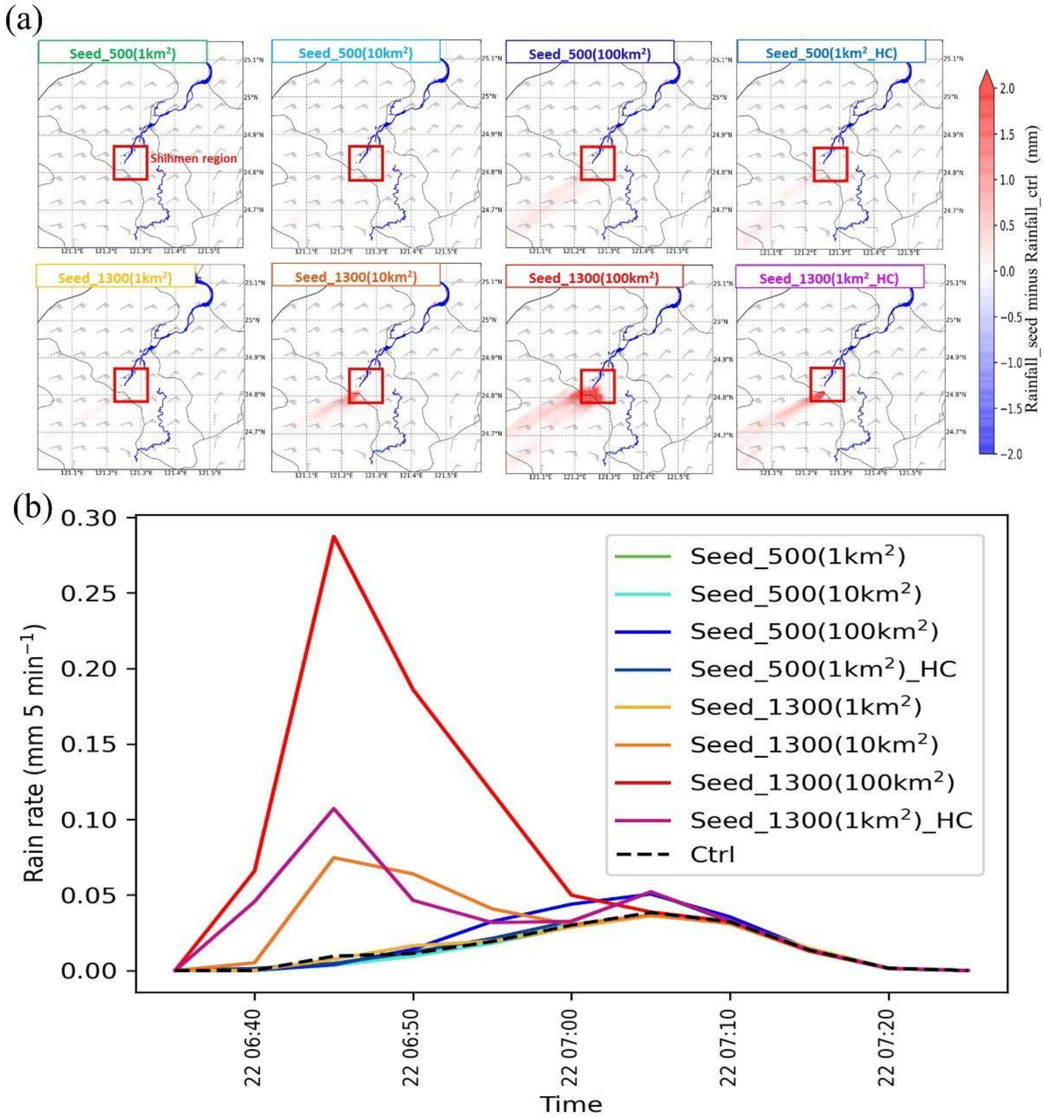

Figure 11: (a) 1 hr rain rate variation after cloud seeding (b) Time series (UTC) of averaged rain rate of the rainy grids in the Shihmen region for seed runs and the control run. The red rectangle in (a) represents the Shihmen region, and the rivers shown on the map are Dahan river and Danshui river.

Line 155: "…, hygroscopic cloud seeding is conducted using drones that carry 10 CSRD flare seeding agents in 10 min (seeding rate: 2.03×104 # cm^{-3} s^{-1}), …"

9. Line 240: Why do you say seeding in such large area (100 km^2) at 500 m is "impractical and ineffective" but at the same time seeding in 100 km2 at 1300 m is "more suitable"? I think both of them are impractical.

   Response: Line 240 mentioned seeding at 1300 m (in-cloud area) is more suitable because it can more effectively enhance precipitation even in smaller seeding areas, not only 100 km^2 (10 km×10 km). We agree that seeding in a 10 km×10 km area may be too large to execute cloud seeding. Thus, we discuss the most effective seeding area in session five of the manuscript.

10. Fig. 13, Why Praut increases in seed_500(100 km2) but Qr does not increase as shown in Fig.11 g, h.

Response: In fact, Qr of seed_500(100 km^2) also increases in Fig. 11 g and h (Fig. A1 a, b), but the value is much smaller than seed_1300(100 km^2). In addition, we find that the evaporation of rain is stronger at 1 to 3 km in seed_500(100 km^2) (Fig. A1 c, d), which might be one of the reasons there is a little Qr enhancement.

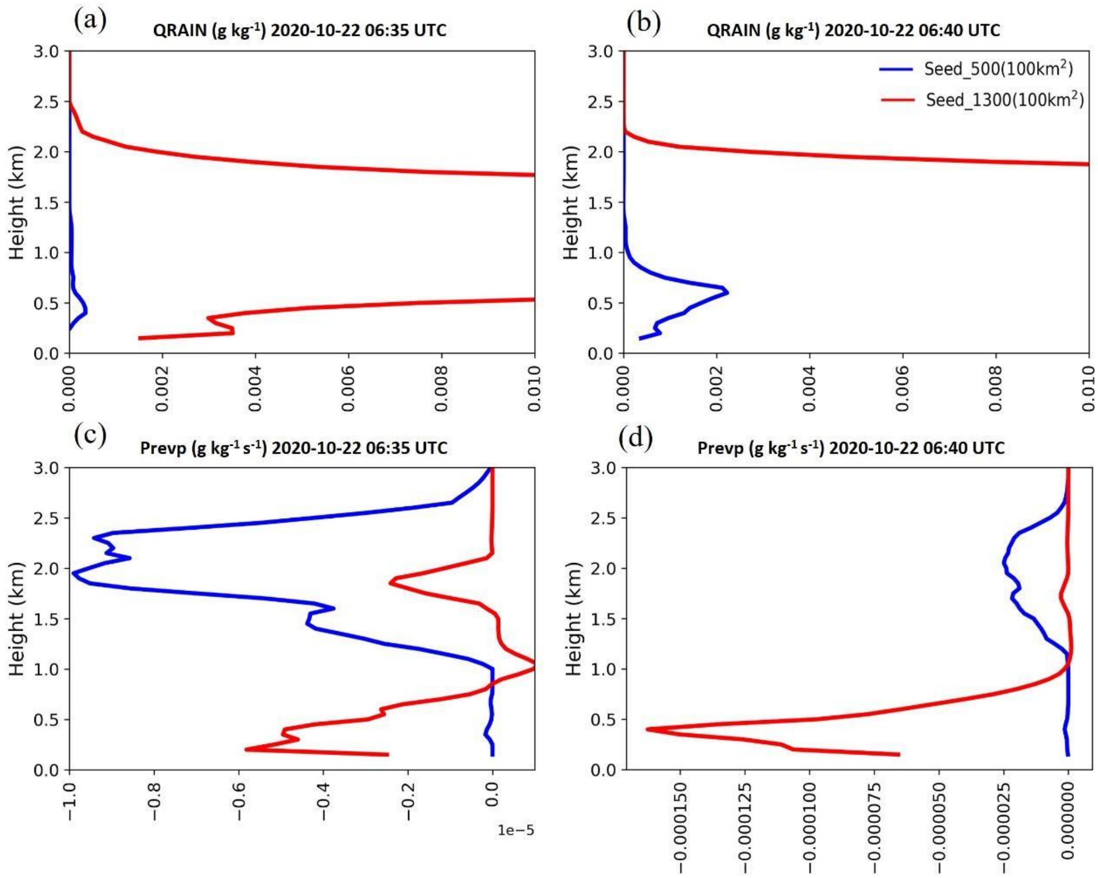

Figure A1: Vertical profile of the averaged difference between the control run and seed runs of the (a)–(b) mixing ratio of rain (QRAIN), (c)–(d) evaporation of rain (Prevp). Blue line represents Seed_500(100km^2), and red lines represent Seed_1300(100km^2).

11. Fig. 15, Why the units of dN/dlog(D) is % **?**

Response: The number concentration of each bin is divided by the total number concentration for the percentage of each aerosol bin. The y-label of Fig. 16 in the revised manuscript is revised to “percent (%)”.

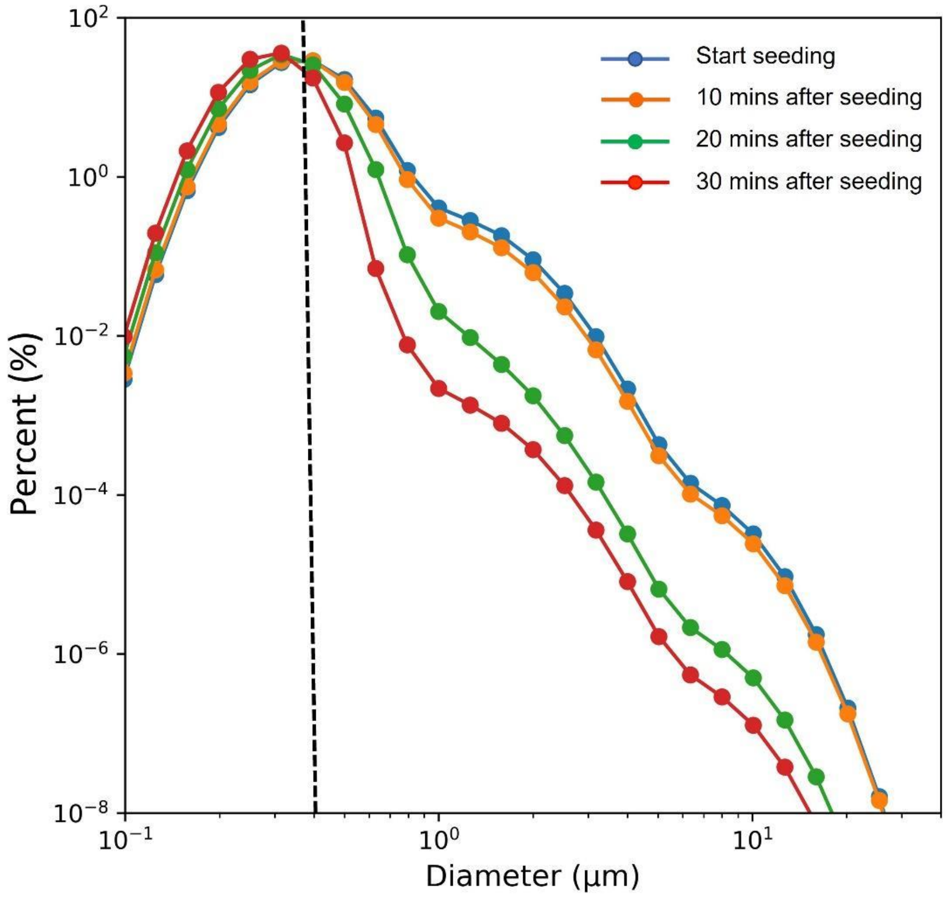

Figure 16: Size distribution of seeded CCNs at different times after cloud seeding. The black dashed line separates the particles larger and smaller than 0.4 μm.

12. Line 261: Why do you think when the seeding area is larger than 64km2, the Shihmen region no longer has plenty of cloud water to transform to precipitation ? Is there any evidence supporting your conclusion ? Didn't you say that seeding leads to an increase in Qc in 10 min?

    Response: This study focuses on the Shimen region defined as a 10 km×10 km area surrounding the Shimen reservoir. In Fig. 16, the variance of Qc is similar in seeding at 64 and 100 km^2, which presents almost the same amount of Qc that can be transformed to Qr in the Shihmen region. Indeed, seeding can increase Qc, however, for Shihmen region, seeding in 64 and 100 km^2 actually have similar Qc enhancement in 10 min after cloud seeding, and consume almost the same amount of Qc to produce precipitation (Fig. A2).

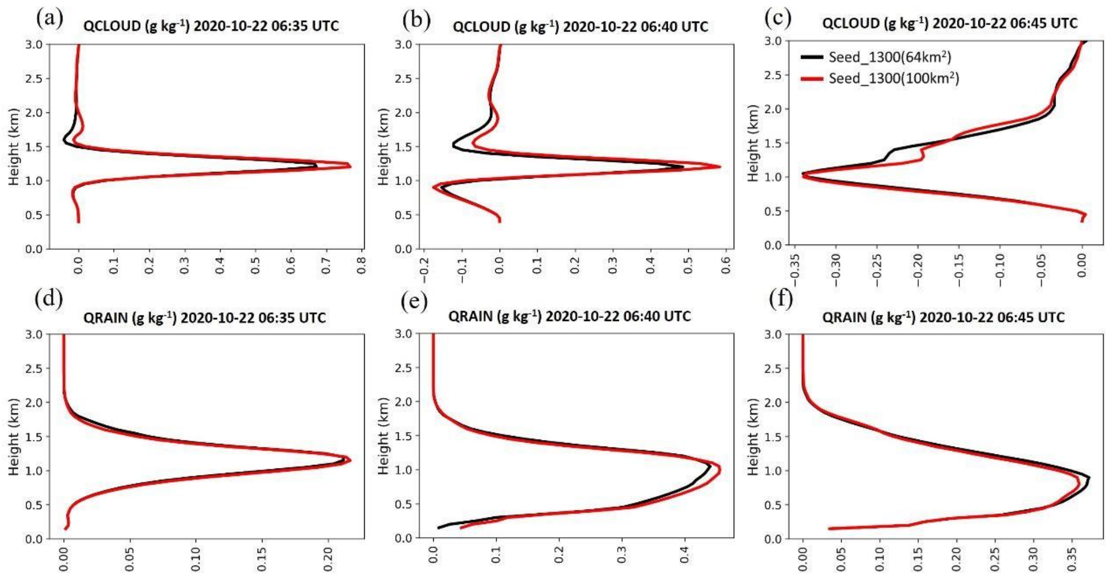

Figure A2: Vertical profile of the averaged difference between the control run and seed runs of the (a)–(c) mixing ratio of cloud (QCLOUD), (d)–(F) mixing ratio of rain (QRAIN). Black line represents Seed_1300(64km2), and red lines represent Seed_1300(100km2).

Reference:

Lee, H., and Baik, J.-J.: A Comparative Study of Bin and Bulk Cloud Microphysics Schemes in Simulating a Heavy Precipitation Case, Atmosphere, 9, 10.3390/atmos9120475, 2018.