Review of "The Critical Number and Size of Precipitation Embryos to Accelerate Warm Rain Initiation" by Lim et al.

This paper presents a numerical investigation into the role of low-concentration, large-sized droplets, referred to as precipitation embryos (PEs), in the formation of rain in warm clouds. The study employs box simulations focused exclusively on the process of collision-coalescence. The authors utilize a "one-to-one" Lagrangian cloud model (LCM), which is an appropriate choice for capturing the detailed mechanisms of collision-coalescence. By modeling small cloud volumes (less than one cubic meter) and excluding other in-cloud processes, the study provides qualitative insights into the role of PEs in rain initiation. However, this narrow focus allows the authors to explore a broad range of droplet sizes and concentrations, as well as the effects of turbulence-induced collision enhancement (TICE).

The results of the study corroborate previously observed phenomena, such as the competition between PEs and TICE, and the particularly significant role of PEs in clouds that otherwise would not precipitate. While the findings themselves may not be particularly groundbreaking, they contribute to a deeper understanding of warm-rain formation. Notably, the paper introduces a useful formalism for determining the minimum number and size of PEs required to influence rain formation. I believe this study is a valuable contribution to the field and would recommend its publication, provided the authors address the following points:

1. **Clarification of Non-PE Concentrations**: It is unclear what non-PE concentrations were used. Based on line 81, these appear to be 238, 456, and 523 droplets per cubic centimeter, but the caption of Figure 1 provides conflicting information. It would also be beneficial to ensure that there is a case representing a clear marine concentration of approximately 100 droplets per cubic centimeter, given that sea-spray aerosols are a known source of PEs.
2. **Range of Dissipation Rates for TICE**: The paper tests TICE for dissipation rates of 16, 80, and 100 cm^2/s^3. However, the values of 80 and 100 cm^2/s^3 are quite similar, and all the tested rates fall within the typical range for cumulus clouds (10–100 cm^2/s^3). It would be more informative to include dissipation rates representative of other cloud types, such as stratocumulus, cumulus, and deep convection, to broaden the study's applicability.
3. **Discussion of PE Characteristics in Real Clouds**: The paper would benefit from a discussion of the expected number and size of different types of PEs in real clouds, along with an assessment of their likely significance in natural cloud systems.
4. **Interpretation of Function ϕ in Equation (5)**: The function ϕ, defined in Equation (5), describes the impact of PEs by combining their number and size. However, it is a decreasing function of PE size and concentration, which makes the plots harder to interpret. It might be more intuitive if ϕ were an increasing function, and if $\phi = 0$ corresponded to the absence of PEs.
5. **Definition of Rain in the 10% Mass Conversion**: It is unclear how rain is defined when calculating the time required to convert 10% of the total cloud mass to rain. Is the initial presence of rainwater (e.g., from PEs already exceeding the rain threshold at $t = 0$ s) included in the 10% mass calculation?

6. **Interpretation of Results Regarding the 'Lucky Droplet' Theory**: The statement on line 190—"This suggests that while PEs can accelerate the formation of the largest raindrops, these droplets may not substantially impact overall rain initiation after the initial period when they are few"—is described as contradicting the 'lucky droplet' theory. However, I disagree with this interpretation. The results show that when there are too few lucky droplets (PEs), they do not significantly impact the time to convert 10% of the cloud mass into rain. Nonetheless, when more lucky droplets are present, they do affect this time ($t_{10\%}$). Furthermore, even if $t_{10\%}$ averaged over small cloud volumes is not affected, the presence of lucky droplets could still play an important role in rain formation in real clouds.

Technical Comments:

- Line 135: There is an unclosed parenthesis.