Title: Accelerated impact of airborne glaciogenic seeding of stratiform clouds by turbulence

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Recommendation: Accept after major revisions

Chen et al. investigates how turbulence modulates the effects of AgI cloud seeding in shallow stratiform clouds over flat terrain. Using LES simulations based on a real seeding event over North China on 20 January 2022, this study creates an artificially enhanced shear layer and finds that increased turbulence enhances AgI dispersion, ice nucleation, and crystal growth, which accelerates faster glaciation. Although stronger turbulence fosters enhanced SLW generation, the rate of ice growth outpaces condensation leading to a rapid depletion of SLW and faster transition to glaciated cloud. Turbulence amplifies short term precipitation directly downwind of seeding, it suppresses further downwind precipitation. This study highlights the delicate balance between turbulent mixing and glaciation in determining the spatial extend and efficiency of cloud seeding impacts. Overall, I felt like the study was well written but could benefit from several clarifications to enhance the study. Therefore, I am recommending major revisions.

General Comments:

In Fig. 1, the visible and infrared imagery show a clear depression in the cloud top along the flight track. However, it would be beneficial to demonstrate whether this displacement is consistent with the large-scale flow pattern. Specifically, could the flight track be transposed or advected downwind using the wind vectors from the ERA5 reanalysis fields shown in Fig. 1a–b? This would better contextualize the observed cloud top depression and support the attribution of the cloud signature to seeding effects.

Similarly, in Fig. 2, the location of the S-band radar relative to the flight track is unclear and should be explicitly marked on a map. The reflectivity evolution shows a clear enhancement along one of the flight legs but not the other—why does the enhanced reflectivity from the eastern leg fade later in time? Was there a difference in cloud properties, wind shear, or moisture that could have contributed to the disparity between the seeded legs?

The choice of background aerosol concentration (N_0 = 4000 cm^{-3}) seems quite high for a wintertime stratiform cloud and may not be representative of the conditions aloft over rural North China. Is there observational support for this aerosol profile? Were vertical variations in aerosol concentration considered, and how sensitive are the results to these assumptions? Given that aerosol background can strongly influence microphysical pathways, this deserves more justification or discussion.

A brief explanation of how cloud was forced and maintained in the model would benefit the reader. While the use of a constant profile and a single sounding is mentioned (Section 2.2), it was not immediately clear how the cloud was maintained within the LES framework, particularly given the absence of evolving large-scale forcing. I found myself needing to read through this section twice to piece together how the cloud structure was sustained. A concise summary early in the model setup section—perhaps explicitly stating the role of the initial liquid water mixing ratio, the static thermodynamic profile, and discussing how cloud was maintained after it was initialized—would improve clarity.

The LES is driven by a single sounding with no horizontal heterogeneity or time-evolving large-scale forcing. This idealized setup limits realism, especially in terms of representing synoptic evolution and mesoscale variability. How might the results differ if the full 3D ERA5 meteorological fields were used to initialize and force the model? Would the cloud form in a similar vertical structure, and would radar reflectivity fields appear more similar to observations? A brief discussion of this limitation would improve transparency.

One of the more confusing aspects of the paper is the comparison setup (especially compared to other seeding studies). The so-called “Control” simulation includes AgI seeding, but there is no true baseline simulation without any seeding. This makes it difficult to isolate the seeding effect, especially since fall streaks and reflectivity enhancements appear in the Control run, which undermines the attribution of microphysical or dynamical responses to seeding. Including a no-seeding case—or clearly differentiating it from the "Control"—would clarify the results and interpretation. I think running a true control and comparing it to the observations and other simulations would add a lot of value to the manuscript.

The simulations use only a one-hour spin-up period before seeding is introduced at 2:00 MT. However, at 2:30 MT (the first output shown in Fig. 7), the cloud field and reflectivity structure still appear immature. For instance, in all simulations including the Control, reflectivity increases dramatically in later time steps. This raises the possibility that early reflectivity enhancements are a spin-up artifact rather than a response to seeding. A longer spin-up or justification for the current choice is needed, particularly since the cloud system being simulated is shallow and sensitive to small thermodynamic changes. Also, in Fig. 7, the radar reflectivity differences between SEED and NOSEED areas are subtle, especially in the early time steps. The seeding signature is difficult to identify without annotations or overlays. Annotating the plots to highlight the SEED plume location, expected signal from seeding, and NOSEED comparison regions would make the figures much more interpretable. As it stands, the reader must infer these spatial relationships without guidance.

While the discussion offers some thoughts on generalizability, the study’s findings are drawn from a highly specific case: a shallow, capped stratiform cloud in a quiescent wintertime environment. The conclusions regarding turbulence-enhanced glaciation and the transition from positive to negative seeding effects may not extend to deeper, more dynamic clouds. A more tempered framing of the conclusions, emphasizing the case-specific nature of the results, would strengthen the overall presentation

Specific Comments:

Line 103 – “...brightness temperature increased by about 2 °C...” Is this value within the noise level of the satellite product? What’s the uncertainty?

Line 116 – "...radar echo appeared about ten minutes after seeding..." Is this consistent with modeled ice nucleation onset time? If not, why not? Feel like this was not discussed later in the text

Line 135: "...periodic lateral boundaries..." Could periodic boundaries introduce artifacts in this stratiform cloud case?

Line 158 – "A single sounding is used to drive the model…" Can the authors clarify when and where the sounding was launched relative to the seeding flight track and time? Was it an operational sounding, and how representative is it of the cloud environment during the seeding event? Spatial and temporal offsets could influence the initial conditions and evolution of the simulated cloud.

Line 164: "...Richardson number...from 16.81 to 0.67..." This is a large reduction. Can you show whether turbulence actually became dynamically unstable (e.g., $Ri < 0.25$)?

Line 265: "...IWC up to 0.06 g/kg..." How does this compare with in-situ observations from similar seeded clouds?

Line 286: "...generation of liquid water was significantly slower..." Can this be quantified more directly using a rate ratio (e.g., production/consumption)?

Line 311: "...cumulative precipitation decreased after 4:40 MT..." What was the baseline precipitation without seeding during this period?