Responses to Comments

We sincerely thank Editor Eriksson, and two anonymous reviewers for the constructive and thoughtful comments.

Comments are in *blue italic lettering*, responses in black.

Reviewer 1 Comments

General Comments:

The manuscript describes and evaluates a synergistic methodology to retrieve ice-cloud microphysics from synergistic radar and radiometer observations and provides. The evaluation is based on synthetic observations derived from a numerical weather prediction model. Overall, I find the manuscript well written and informative. However, the fact that radar and the radiometer are characterized by significantly different Field of Views (FOVs) should be addressed (or at least thoroughly discussed) in the manuscript. Specifically,

The radar considered in the manuscript is a nadir-looking instrument similar to the Cloud Profiling Radar (CPR) of the CloudSat mission, while the radiometer is a conically scanning instrument with a view angle of 450 from the nadir. While the radiometer's horizontal resolution is not specified, it is presumably coarser than that of the radar. It is not clear from the manuscript whether this aspect was considered in deriving the synergistic retrievals. In principle, one can account for the fact the that two instrument's FOVs are not the same, but the performance of the retrievals or the computational effort may be significantly different from those obtained when using simplifying assumptions. This should be discussed in the manuscript.

Thanks for your general comments very much, and sorry for not mentioning the difference in horizontal coverage and viewing geometry between the active and passive sensors in the previous manuscript. This study focuses on investigating the synergistic retrieval performance when the fields of view are perfectly coincident. We have added specific statements in section 2.4 for the assumptions, as shown in Lines 113-120 in the revised manuscript. We also mention the simplifications in the summary section, as shown in Lines 507-510. The questions regarding the influence of footprints and viewing angles are great, and we will try to address them in future work once those characteristics are known.

Minor Comments:

Page 5, Line 110. How exactly are the radiative transfer calculations done? Is the plane- parallel assumption made? Are any attempts to account for 3D effects made, such as slant-path calculations (Bauer et al., 1998)?

The radiative transfer model in this study runs at the 1D atmosphere mode. As mentioned above, we assume that both sensors always have the same fields of viewing at nadir angle, and the 1D atmosphere could work well under such simplifications. The discussion could also be seen in Lines 113-120. 3D simulations are much more advanced in actual retrievals, but they are beyond the scope of the present study.

Page 7, Line 155. I assume this means a finite difference scheme. If so, it is probably better to just call it a finite-difference scheme, as perturbation may be confused with the ensemble approach.

This sentence has been rephrased to state the finite difference approach. The meaning of perturbations in the revised context should be clear now. Please check it in lines 160-162.

Page 14, Line 323. These results are rather idealized than analytical.

The present idealized retrieval experiments are done under a lot of assumptions such as the same fields of viewing, very simplified cloud species, single ice cloud habits, etc. We indicate these simplifications in different sections such as lines 109-111, lines 113-120, and the lines 507-510. We will keep improving the forward model and retrieval algorithms in the following work.

Page 15, Line 335. Water vapor may be a significant source of uncertainties in the radar retrievals. It would be useful to investigate how the radiometer-retrieved water vapor impacts the synergistic retrievals.

Thanks for your suggestion very much. Water vapors influence radiative transfer in (sub)millimeter significantly, and it is definitely worth investigating this problem more deeply. We currently only have IWC and NC as the state variables in the synergistic retrievals, as indicated in section 3.3 in lines 296-300. We mention that we neglect the impacts from water vapor variability in the summary section, as shown in line 525. A general way to see the impact of the water vapor in radiative transfer is through the figure 8, which shows the Degrees of freedom as a function of the integrated water vapor. More complicated simulation experiments will be done in the following studies to make the ACCP assessments more realistic.