In the present study the authors attempt to identify the potential mechanisms leading to the dissipation of a mixed-phase boundary-layer cloud in the high Arctic. The model simulations presented in the paper are based on an observed case from the recent ASCOS field campaign. The authors examine several processes that might be contributing to the cloud layer dissipation and conclude that the most likely reason is the reduction of cloud droplet concentration as a result of diminished background aerosols.

The paper is very well written and easy to read. At the same time, while I do appreciate the authors' effort to keep the paper short and up to the point, I think that it would benefit from expanding the analysis of the simulations and including some additional figures.

I would agree with Reviewer #3 that the lack of observational verification is a major limitation of this study. Although the authors specifically state that their study exploits the observations collected during ASCOS, there is only a radar reflectivity plot and a moisture sounding presented in the paper. I doubt detailed in-situ microphysical data are available for this case but perhaps some observations or reanalysis results characterizing the large-scale environment, which to a large extent determines the evolution of the cloud layer, could be included.

Overall, I would recommend publication after the following comments are addressed in the revised version.

Major comments:

1. Since the CCN-limited regime is the main focus of the paper, I would expect that all simulations would be carried out using prognostic CCN instead of fixed CDNC. I consider this a major flaw that obviously warrants some discussion in the paper. What are the potential implications and limitations of this approach? For example, I would assume that with prognostic CCN the cloud layer would start diminishing at much higher background aerosol concentrations.

2. I'm not sure I understand the rationale behind the SensMoist sensitivity simulations. If the intent was to mimic a large-scale drying advection, then why modify the initial moisture profile and not just impose a forcing term that would dry the domain out throughout the simulation? Changing the initial moisture profile doesn't seem to be a very realistic representation of drying large-scale advection. Is the magnitude of this drying consistent with ECMWF reanalysis or following ASCOS soundings?

Also, how realistic is it to impose drying advection either only below or only above the cloud layer? Obviously, there are two sources of moisture in the simulations – one above the cloud layer and one below; therefore turning them off one by one does not seem to be an effective way of turning the moisture supply off. Speaking of moisture sources, what are the surface fluxes in the simulations?

I would also strongly suggest including the vertical $q_v$ and moisture turbulent flux profiles when discussing the simulations.

3. The analysis of SensCDNC simulations seems a bit dry. I would suggest expanding it, as this is the main point of the paper. Without knowing the simulations in detail, I could speculate that the effect of decreasing CDNC is most likely "indirect", i.e. lower CDNC leads to lower LWC, and consequently less radiative cooling, weaker cloud layer circulation that cannot penetrate and mix the inversion at 300m, thus preserving the initial two-layer structure. In this configuration, the top cloud layer is isolated from the moisture source below, the moisture source above is weakened by the decreased entrainment and the cloud layer begins to dissipate. The bottom layer, however, seems quite robust and does not show any signs of decay, which obviously contradicts the observations in Fig. 1.

Minor comments:
1. Pg. 4 ln. 5: I assume that the horizontal grid spacing is 100m, not the model resolution. Correct? The same on ln. 7 for the vertical grid spacing.

2. What is the ice particle habit used in the simulations? Is it consistent with observations and/or temperature regime?

3. Pg. 5 ln 30: "When a cloud droplet grows …" – perhaps the model description section would be a better place for this sentence?