Review of manuscript **acp-2022-36**: *Do arctic mixed-phase clouds sometimes dissipate due to insufficient aerosol? Evidence from comparisons between observations and idealized simulations* by Sterzinger, L. J., Sedlar, J., Guy, H., Neely III, R. R., and Igel, A. L.

Overview

Overall, this revised manuscript shows a clear improvement from the initial submission. The methodology of the study is now explained sufficiently and the results are now presented in a better way. That said, there are significant "disagreements" between what is described in the revised manuscript (section 2.3) and what is the setup of the model study (doi.org/10.5281/zenodo.6514322). Furthermore, chosen methods lead to certain limitations of this study, but this is currently not reflected in the conclusions.

Therefore, in the current version of the manuscript, some parts of methods are misleading. Authors are kindly requested to correct the description of their methodology and briefly clarify the limitations of their study in the conclusions.

1 Overall recommendation

Publish after minor revisions

2 Minor Comments

2.1 CCN concentrations

The description of the CCN concentrations in the manuscript differs from the prescribed subsidence in the model setup files (repository https://doi.org/10.5281/zenodo.6514322).

Table 1:
The initial concentration of CCN in the SMT case is listed ad 200 cm^{-3}.

Meanwhile, model setup (SMT-RAMSIN) lists the same CCN concentration as in the OLI case.

```
CCN_MAX = 80., !  CCN (#/mg) normally 170
```

This value also appears in the horizontally averaged concentrations in the model output.

It is of course understandable that authors used similar CCN concentrations in all three cases. However, this has to be clearly stated and also briefly justified.

2.2 Subsidence

The description of the subsidence in the manuscript differs from the prescribed subsidence in the model setup files (repository https://doi.org/10.5281/zenodo.6514322).

lines 231–233: "..Large-scale subsidence is applied throughout the simulation by imposing a horizontal divergence of $2 \times 10^{-6} \mathrm{s}^{-1}$ at every model level, with a boundary condition of $w_{sub} = 0$ at the surface."

Meanwhile, model setup (ASCOC-RAMSIN, OLI-RAMSIN, and SMT-RAMSIN) do not prescribe this subsidence, but rather large-scale convergence:

```
CDIVMAX = -6.1224e-6, !  Divergence amplitude (s -1) (negative = convergence)
```

This large scale convergence also appears in the horizontally averaged vertical velocity in the model output.

This is still and interesting example of an idealized model setup. Nevertheless, the description in the methodology has to be corrected.

2.3 Description of Albedo

The Experiment Setup (2.3) does not describe the surface albedo. While some of the cases take place during the polar day, the surface albedo is an important property in the radiative scheme.

The model setup prescribed albedo value 0.5 (ASCOC-RAMSIN), respectively 0.6 (SMT-RAMSIN).

These albedo values should be described in 2.3 and justified.

2.4 Comparison Figure not Consistent

The figure 5 shows an important comparison of all three cases. Unfortunately the time point of CCN removal differ across it figures. The time scales differs as well.

This figure would be much more useful if the time points and time scales were synchronised across all three panels (in a similar way as it is in figure 6).

This figure would furthermore benefit from being larger in size.

2.5 Turbulent Decay to Non-LES Regime

In some of the simulations, the dissipation of the clouds leads to decay of turbulence.

This could be clearly seen in the horizontally averaged variable `TKEP` in the model outputs. By the end of one of the simulations, it drops to values 0.0005–0.0009 $\mathrm{m}^2/\mathrm{s}^2$, which is almost the same value as in the non-turbulent free atmosphere above the boundary layer (0.0005). This indicates that the subgrid scheme no longer approximated the turbulent cascade and the model no longer resolves large eddies.

While this is totally acceptable result, it would be fair to state in the Discussion and Conclusions that the LES by the end of the simulation does not operate in LES regime, but rather as a fine-scale convection-permitting model.

2.6 Coupled Boundary Layer

Line 408:
"...coupled boundary layer (OLI)..."
This statement is in a direct disagreement with the description on line 204:
"...surface fluxes are disabled..."

Perhaps it would make sense to correct line 408 to "previously coupled" or "recently decoupled".

2.7 Strong Conclusion Statement

Line 422–424:
"We believe that, given the evidence from these three simulations, the microphysical balance state of the cloud may be more important to determining the response to aerosol removal than boundary layer properties"

The conclusions should clarify for which group of boundary layers this applies
(decoupled, & polar day, &, large scale convergence, & weak windshear, etc.).

2.8–12 Further Minor Comments

- line 238
  The word "decase" does not seem to fit the context here.

- Figure 7, panels a and b
  The timeseries "precip" differs between the panels.
  Either there is a numerical mistake, or the captions is incorrect in the sense that "precip" refers to two different variables.

- Figure 8, panels a and b
  Same as for Figure 7a,b.

- The figures 7, 8, and 9 show very important results, but the panels are very small. Please expand them.

- Code and data availability.
  The links should be updated to the newest version of repositories.