Reply to referee's #2 comments on manuscript:

The paper examines summer-time Arctic boundary layer clouds, observed during a shipborne campaign. For a few hours clouds showed a two-layer vertical structure. The paper uses LES to reproduce the observations and to also perform a sensitivity analysis. The authors find that decreased aerosol concentrations and greater windspeed would erode one or the other layer.

The paper is well written and the figures are of good quality. I have one major and a few minor recommendations that the authors should resolve before publication.

We thank the reviewer for carefully reading the manuscript and the constructive comments.

Major comment

Section 4.2.3: Given the great sensitivity to windspeed, the topic appears under-explored. Perhaps the authors could provide additional information that helps to understand how erosion of the lower cloud layer was facilitated:
How much of increase in surface turbulent heat fluxes was found for greater windspeed?
How did the TKE profiles change across simulations?
What explains the increase in column total water?

We agree with the reviewer that this topic could have been explained in more detail.
In the simulated case, there is generally a small surface heat flux because the boundary layer (BL) is in principle well-mixed (i.e. near-neutral temperature profile). With weaker (stronger) wind speeds, there is less (more) mixing but it doesn't alter the surface turbulent fluxes much as long as the BL is already well-mixed (this has also been checked and confirmed by the model output). The changes in the wind speed modulate the mechanical mixing; it is larger with higher wind speed and vice versa. More substantial mixing in the experiment with higher wind speeds thus adds additional mechanical turbulence to the buoyancy turbulence. It leads to erosion of the lower part of the BL, coupling the upper cloud layer with the surface and inducing more entrainment. These changes also affect the LWP.

In the Sect. 4.2.3, it has now been added: "With stronger winds (i.e., wind_8.5), there is more mechanical mixing from the surface, which erodes the lower-altitude temperature inversion (not shown) and causes the lower cloud layer to dissipate after ~4 hours of simulation (Fig. 15c). This further connects the whole BL layer and induces more entrainment over the top of the upper cloud layer. The net effect is a single-layer cloud structure in a slightly deeper BL with a somewhat higher cloud top. This change also affects the LWP, which is reduced both by the dissipation of the lower cloud layer and by the somewhat lower cloud water concentrations in the upper cloud layer; this also reduces the IWP (see Fig. 14a and 14b). Interestingly, this difference to the control run is present immediately after the spin-up, when only a weak moisture inversion is present; this is then enhanced as the BL deepens and the moisture inversion strengthens. Presumably, the entrainment of warmer air accumulated over time has a larger effect decreasing the cloud liquid water than entraining of absolutely moister air across the cloud top. With the lower wind speeds (i.e., wind_3.5 simulation), the opposite happens. There is less mechanical mixing and therefore a shallower surface-based BL develops. In this shallow BL, a lower cloud layer forms capped by a lower-altitude inversion, which decouples the upper cloud layer from the surface."

We have decided not to add additional figures since the manuscript is already figure-rich.

Minor comments

Fig. 1: For geographical context either Latitude lines or labels of nearby landmasses would be helpful.

We have added labels of nearby landmasses.

Fig. 5: Perhaps changed y label to dN/dlogDp.

The modal integrals under the fitted curve correspond to dN values, which are also the numbers used as the model input parameters (shown in Table A1). Using dN/dlogDp would not correspond to the numbers we used in our simulations. We understand this was not explained well in the previous manuscript version. Thus, we have added: "Note that the dN values shown in Table A1 represent the modal integrals under the fitted curve in Fig. 5 (y-axis; dN/dlogDp multiplied with dlogDp) and are the numbers used as the model input parameters."

Section 2.2: A few details should be added here:

How was temperature and moisture advection handled?

In the Model section, it has now been added: "The scalar advection follows a Lex-Wendroff flux limited method described in Durran (2010) with periodic boundary conditions but horizontal large-scale advection tendencies are set to zero.".

Was aerosol treated diagnostically or prognostically?

In the previous version of the manuscript, it was written: "The model includes a two-moment aerosol module with a prescribed number of lognormal aerosol modes (Ekman et al., 2006).". We have modified this: "The model includes an interactive two-moment aerosol module where an arbitrary number of lognormal aerosol modes can be defined (Ekman et al., 2006). Aerosol particles that are activated into cloud droplets can be scavenged from the model domain through precipitation. The aerosol mass within hydrometeors is tracked by the model and is released back to the atmosphere when hydrometeors evaporate or sublimate.".

Does the simulation consider the water vapor and ozone column above the model domain?

Yes, we have used a standard polar atmosphere profile above the top of the model domain, including both water vapour and ozone. This information has now been added to the Sect. 2.2.

Was the diurnal cycle of solar insolation taken into account?

Yes, this information is now also added to the Model section.

ll. 308-309: Please explain which instrument or technique was involved in estimating hygroscopicities.

In the new version of the manuscript, we have added: "The estimated kappa values were based on *in situ* observations of aerosol particle chemical composition, using a thermal desorption chemical ionization mass spectrometer (TDCIMS), for the period of interest. The calculation used a composition-weighted average of assumed kappa values for the various constituents determined (e.g., sulfuric acid, assumed kappa=1.19; ammonium bisulfate, assumed kappa =0.8)."