Review of “The Transition from Supercooled Liquid Water to Ice Crystals in Mixed-phase Clouds based on Airborne In-situ Observations”, by Maciel and Diao.

This is an interesting and I’d say novel study that characterizes the degree of glaciation of supercooled clouds in the Southern Ocean, using data from the SOCRATES field program. They use a combination of “bulk” data from the 2DS and CDP probes, augmented with the King liquid water content and Rosemont Icing Probes for phase discrimination. The methodology is based on Yang et al. (2021), which is based on D’Alessandro et al. (2019). A second method uses the 2DS images and a machine learning tool to identify individual images of liquid and ice particles. The methodology and some of the results bear a striking similarity to the Yang et al. (2021) article. This includes the relationship of the phase partitioning to the aerosol concentration. Some mention of the results of that study should be given and how the techniques and results differ.

The partitioning of the data into liquid only, mostly liquid, mostly ice and all ice phases is interesting, and relating it to the macrophysical properties of the cloud layer (ice content, relative humidity with respect to water and ice, and vertical velocity is interesting. Likewise, the ice fraction partitioning is rather interesting.

I tried to think of the factors that determine the glaciation of a stratiform cloud layer. First, in stratiform ice cloud layers, typically liquid water regions, the stronger vertical motions, and ice nucleation mostly occur at cloud top. Below cloud top and depending on the vertical velocity which is responsible for the degree of ice supersaturation or subsaturation, can contain a growth or sublimation layer. The measurements you report on do not account for where vertically within the cloud layer relative to cloud top the aircraft penetrations were made. Thus, you may be sampling in a subsident or upward moving parcel of air. Perhaps your measurements at temperatures below -15^{0}C are near cloud top, and those at the warmer temperatures in the middle or lower parts of the cloud layers. The relationship of the relative humidity to turbulence might be a manifestation of where in the cloud layer the sampling is done, and whether generating cells were penetrated. You do mention that the aircraft observations only captures the 1-D structure of a cloud segment, while cloud layers above and below the aircraft flight track may show a different ice spatial ratio on a 2-D or 3-D view. Nonetheless, I think a weakness of the study is that there is no partitioning of where in the cloud layer the measurements are made. (Note that it’s unlikely that the vertical motions measured by the aircraft system are sufficiently accurate to determine what zone the measurements are made in, unless generating cells are penetrated).

Figure 10, which shows the distributions of RHi, RHliq, vertical velocity and standard deviation of vertical velocity which be presented before Figure 3 as it provides a context for how the various transition regions relate to the large-scale properties of the cloud layer. What is shows is that transition region 4 is subsaturated. This why there is no liquid water in that region, not a stage of development of the ice cloud. It also shows up in the PSDs-transition region 4 has fewer ice particles and smaller maximum ice particle sizes than transition region 3. These might be the trails of generating cells, where the growth is aloft and sublimation lower down in the cloud layer.

Minor comments

Line 6: determines the "ice cloud lifetime"
45: resilience to what?

62: "growing"?

66: aerosol

97: remove "various"

183: I don't think the CDP can reliably differentiate liquid drops from small ice

186. Phase 4. Perhaps this is due to aggregation reducing the concentration of ice crystals. Another possibility is that this region is subsaturated. Indeed, the RH_i in transition region 4 is subsaturated.

190. This is likely due to sublimation in transition region 4.

Section 3.4. This is similar to the Yang et al. (2021) study.

260: Phase 4 has the lowest RH_i and RH_{liq} values. In fact, it is subsaturated at most temperatures (Fig. 10a). Consider moving Section 3.5 much earlier, perhaps before charactering the different transition phases. It explains a lot.