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Review - acp-2021-926

Anonymous Referee #3

Referee comment on "Exploring relations between cloud morphology, cloud phase, and cloud radiative properties in Southern Ocean's stratocumulus clouds" by Jessica Danker et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-926-RC3, 2022

In this work, the authors use the multi-satellite DARDAR-MASK product together with a neural network identification of mesoscale-cellular convective clouds to characterise the relationship between cloud morphology (represented by the MCC type), cloud phase (from DARADR) and cloud radiative properties (calculated from the retrieved optical depth). They show that cloud phase depends more strongly on cloud depth than cloud top temperature and that cloud phase is also connected to the MCC type, leading to potential implications for cloud phase feedbacks.

This manuscript shows a number of clear results, supporting studies based on ground-based or insitu data that were primarily previously conducted in the northern hemisphere. I have a few minor points and suggested, but other than this, the paper is clearly in scope for ACP and I would recommend publication after these are addressed.

L47 - Are favored?

L78 - Some previous studies have only used DARDAR phase at the cloud top. How reliable is the phase deeper into the cloud where the lidar has attenuated (or does this not matter)?

L89 - does g change for ice or is the same value used for all clouds? The connection to optical depth would also presumably depend on the value assumed in the retrieval.

L95 - What is mix? My understanding is that it is a lidar backscatter peak along with a radar return. Is it possible that this is not actually mixed phase cloud, but perhaps precipitation (or just large liquid water droplets)?

L107 - Presumably Ice only is also a vertical 'phase' that occurs - or is that excluded?

L121 - Is there an example of this? I would have thought the MODIS CTT might be a better option, as at least for these low clouds, MODIS is actually observing the temperature, rather than reconstructing it from the p-T relationship in ERA5? Is the uncertainty perhaps due to cloud phase errors?

L165 - I am not sure what is going on here. The paragraph suggests that Mulmenstadt et al find more precipitating clouds the the current study, but also that they rarely find precipitating clouds (although more often than this study). Is it clear why these studies disagree given they both use very similar data)?

Fig. 3 - When the circles overlap (particularly on the top right), it can be difficult to see how they change. It also makes it difficult to determine how the mean phase fraction changes too, as the central points are black for both mixed and liquid.

L254 - 'could be related to' - you have the data to show if this is the case I think? This paragraph jumps about a bit between potential explanations and new results, it might be easer re-ordered slightly (although I leave that to the authors discretion).

L285 - the decrease in mixed fraction for the observed mixed fraction - this sentence is a bit confusing. It might be useful to be more explicit about which direction the mixed phase fraction is changing with temperature (and which bit you are considering here).

Fig. 4 - L291 states that there is not a higher mixed phase fraction is open than closed MCC clouds. This figure appears to demonstrate that the opposite is the case, and that there is a considerably higher mixed phase fraction in closed MCC, once latitude and CTT are accounted for (if I am reading it correctly)? Is it possible that Fig. 3 shows little difference because it is not stratifying by the correct variables?

Fig. 5 - Given you need several levels to identify a liquid phase top, but the cloud must have a CBH above 780m. Similarly, presumably at least one cloudsat layer outside the clutter is required - does that also set a minimum useful CTH? Might this contribute to the sharp shift in cloud phase for the thinnest clouds (CTH <1km)?

L371 - How much of this is due to different sampling of 'cloudy' pixels with the MODIS algorithm? Are enough cloud edge pixels discarded in the open cell regime to make a difference here (as presumably almost all closed cell pixels have a valid retrieval?)