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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The Prevalence of Precipitation from Polar Supercooled Clouds" *by* Israel Silber et al.

Anonymous Referee #1

Received and published: 15 December 2020

The authors analyzed multi-year data sets from NSA and McMurdo Station to investigate how often clouds are precipitating. In general, this is a very valuable and relevant contribution. The text is well written even though I think the manuscript would gain some clarity if the sentences would be less complex. The quality of the figures is very good. I enjoyed reading the paper and I have only two major comments. Given that both comments are of rather philosophical nature, I recommend the paper to be published subject to minor revisions.

Major comments:

Definition of cloud base: I'm aware that it is extremely common when dealing with mixed-phase clouds to define only the upper part as a cloud where liquid is present. Given that clouds are defined by their optical properties (the AMS glossary requires

them to be 'visible'), I'm not sure whether this is always a smart choice. Maybe, the authors are aware of that dilemma because they refer only to supercooled clouds. This makes it technically correct, but this means the authors manage to write a paper about mixed-phase clouds without using the term 'mixed-phase cloud' a single time! I would recommend to think about this choice because mixed-phase clouds is an extremely well-established term and avoiding to use it makes a paper less visible (think of people looking for relevant mixed-phase papers with Google Scholar). One way to circumvent the cloud base dilemma would be to use the term 'liquid cloud base'. Alternatively, I would recommend to explain why the term mixed-phase clouds is not used.

L128 'detectable sizes': This is actually related to the upper comment. The authors do a great job in simulating the capabilities of various space-borne sensors. But I would recommend to go one step further in the discussion: I'm missing a discussion about a meaningful threshold for precipitation. Precipitation radars (operational radars, MRRs) typically have sensitivities around 0 dBz, and this is sufficient if the goal is to measure the mass flux at the surface. A reflectivity of -50 dBz already corresponds to an almost negligible mass flux, but what if the authors had a radar with infinite sensitivity that can detect a single ice crystal falling from a supercooled cloud over the course of 15 minutes? Would the authors call this a precipitating cloud? I would expect that almost every mixed-phase cloud can generate a single precipitating crystal, i.e. is precipitating when using the definition of the authors. For the case of a radar, with infinite sensitivity, wouldn't the classification be less about distinguishing between precipitating and non-precipitating clouds and rather be about distinguishing between mixed-phase clouds (with ice formation) and purely liquid clouds? And if this is true, until what Ze value does that hold? -50 dBz? 0 dBz? Thinking about this, I have the impression the authors rather developed a classification to distinguish between mixed-phase (or ice forming) and purely liquid clouds.

Minor comments

L67: When analyzing large data sets, results can depend a lot on the choices made in

the very beginning. Why did the authors choose a 50% threshold and are the results robust to that?

L73: Averaged in linear or logarithmic space?

L90: Because the data set lengths are quite different, I would recommend to repeat the study period or use relative occurrences.

L144ff: Given the lack of INP measurements, I would recommend to trim this discussion or to include other potential mechanisms such as INP recycling.

L159: wrong figure reference

L165: The authors use 'not shown' quite often even though the discussion is interesting and would benefit from a figure.

L220f: I cannot follow the authors here, because precipitation rate is also correlated to a lower size distribution moment

L221: I would recommend to be more specific about the similarities, e.g. in L152 the differences are stressed.

L234: I'm not sure I can follow here: Is there any precipitation rate that is *not* important for the in-cloud moisture budget? In my opinion, even a precipitation rate of 0 is relevant for the budget.

Fig 1: The size of the symbols in the legend is very small

Fig 2b: I found this figure initially very confusing: First, I thought the authors show the likelihood of observing a (precipitating or non precipitating) cloud in a given month. Instead, it is how the observed clouds are distributed over the year. I would recommend to state this more clearly in the caption.

Fig. C3: It is a nice case, but I'm not sure why it is shown?

Fig. D1: The sign convention is opposite to the one reported in L83.

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