

Interactive comment on “Antarctic clouds, supercooled liquid water and mixed-phase investigated with DARDAR: geographical and seasonal variations” by Constantino Listowski et al.

Anonymous Referee #1

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Review of the manuscript "Antarctic clouds, supercooled liquid water and mixed phase investigated with DARDAR: geographical and seasonal variations" by Listowski, C., J. Delanoë, A. Kirchgaessner, T. Lachlan-Cope and J. King

Summary

The study uses DARDAR product (combined satellite-based radar/lidar product) in order to characterize Antarctic tropospheric clouds - distinguishing between supercooled liquid clouds, ice-only clouds, and mixed-phase clouds. A detailed description of spa-

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tial distribution, regional behavior and seasonal differences is given. The authors also show the vertical distribution of cloud phase (averaged over 4 years for various transects) and discuss their relationship to temperature. Relationship to sea ice fraction is also explored. Further, a detailed discussion is included (based on literature) about the role of sea ice and snow in IN and CCN production important for cloud phase.

This is a very comprehensive and thorough study bringing both important results and a very useful database to the Antarctic atmospheric community and I recommend the paper for publication. Below I list my minor remarks to improve the readability of the paper.

Minor remarks:

Title: In its present form - I think there a comma needed after "mixed phase": "Antarctic clouds, supercooled liquid water and mixed phase, investigated with DARDAR: geographical and seasonal variations"

However, the title now sounds somewhat restrictive as the authors investigate also ice-only clouds. They authors may consider modifying the title to make it more inclusive of the presented results

page 1:

Abstract:

L 3: "It is the largest over water" => ... over water surface compared to...

L 3-5: please rewrite to make it clearer

In the abstract a clearer distinction has to be made between SLW, USLW, and MPC.

Introduction:

L 21 "Down to the Antarctic Seas" - please rephrase

L 24: "dilemma can be solved" (instead of will)

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page 2:

L 7: remove -> removes

L 12: "... track the formation of SLW and the mixed-phase clouds Antarctic-wide" I suggest to add a reference to Lawson and Gettelman 2014 (already in the reference list) who showed the importance of the Antarctic SLW on radiative fluxes both in observations and models, and rephrase the sentence above to emphasize more the existing efforts "to track the formation of SLW and the mixed-phase clouds" from ground-based observations, eg the papers already in the reference list (Lawson and Gettelman 2014, Van Tricht et al 2014, Gorodetskaya et al 2015, Silber et al 2018) and others.

L 16: "cloud science" -> "observations" L 17: I suggest deleting "As a matter of fact"

page 3: L24: "finally sea ice exerts control over the moisture and heat transported..." - the authors can also mention the importance of sea ice and drifting snow in providing cloud nuclei

Section 3.2 Methodology

page 10:

L 14: "above the surface" - please specify which surface - ground level or mean sea level, and implications for the defined cloud levels.

3.3 Ceilometers dataset page 11, L 18: "with a horizontal resolution of 50ft" - I suppose the authors meant vertical range resolution. Please say in meters

As the authors correctly note, there are problems with Vaisala algorithm's identification of cloud base heights in Polar Regions, especially for ice clouds (Van Tricht et al 2014). I suggest adding a justifying sentence that in the present manuscript only cloud fractions derived from ceilometers are compared to the DARDAR product (and no distinction is made for CBH for ice or liquid-containing clouds), and for this application Vaisala algorithm should be enough.

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Section 4 Results

page 12, L 13-14: "The deepening of the ASL in winter (Fig 2c) consistently leads to an increase in the CLD fraction over the WAIS (Fig. 5c)." - I suggest replacing "consistently leads" with eg "associated with" as the authors do not show the direct causality between ASL and WAIS cloud fraction, and other factors can be playing a role. My concern is also about the distinction between the "ice-only clouds" and blowing snow. More frequent and more intense storms in winter can be associated with increased blowing snow events - can those be interpreted as "ice clouds" by DARDAR algorithm and contribute to the increase of the "ice clouds" in winter?

The connection between the deepening of the ASL and increased cloud cover in winter over WAIS has to be supported by literature discussing the increased inland moisture flux associated with increased synoptic activity in the Amundsen Sea region. See eg, Dufour et al 2018 and references therein: Dufour, A., Charrondière, C., and Zolina, O.: Analysed and observed moisture transport as a proxy for snow accumulation in East Antarctica, *The Cryosphere Discuss.*, <https://doi.org/10.5194/tc-2018-156>, in review, 2018.

page 13, L 26: MBL - please write in full Marie Byrd Land (used only once in text and the abbreviation introduced in figure caption) - same for RIS (used here but introduced only on page 19) and AIS.

I suggest to avoid using so many abbreviations and write the geographical region names in full, as there are already many abbreviations used for cloud properties. It becomes difficult to read the text at some point. Also better avoid using abbreviations in section titles.

Figure 6 caption: "...distribution of the total all-ice cloud fraction"

page 15, L 1: The MPC fraction and the USLW cloud fraction..."

The above two comments about using the word "cloud" concerns the entire article:

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mentioning of the cloud phase shall be accompanied by the word "cloud" - sometimes it is obvious, but in some places can be confusing. This can be included directly in the abbreviations, Eg, MPC already includes "clouds" (mixed-phase clouds), while SLW doesn't => changing to SLWC or using "SLW cloud" and similarly for other abbreviations concerning cloud phase.

page 15, L 13: isothermes => isotherms

Section 4.2 page 15, line 26: "The reduced statistics due to the radar blind zone and lidar signal extinction [delete and] across the Antarctic"

Section 4.3, page 20, L7 (over the whole Antarctic region), L11 (for the Antarctic as a whole) - please specify if this means the entire region of the study (Antarctic ice sheet and Southern Ocean and until which latitude) or only the Antarctic ice sheet. As the average value is rather high (68%) I suppose it is the former (Antarctic ice sheet +SO).

Figure 9 caption: please provide the abbreviations also in the caption

Section 4.3.2, page 22, L 26: "The monthly evolution of continental clouds is essentially driven by ice clouds, notably large frontal systems devoid of SLW, as shown in the example in Figure 3b." - I am not sure what the authors mean by "notably large frontal systems devoid of SLW"? Frontal systems associated with extra-tropical cyclones can also bring liquid-containing clouds and the example on Fig 3b shows only one winter case dominated by ice.

Section 4.4.2, page 28, L 21-22: ".. the ice phase in the DARDAR-MASK products include both, cloud ice and precipitating ice" - does it also include blowing snow lifted from the ground in the absence of precipitation?

Section 5.1, page 35 L 5: "... the Antarctic-wide SLW fraction decreases 5 from 47 % in summer to 23 % in winter (Figure 9b)"

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2018-1222>,

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