Vertical distribution of microphysical properties of Arctic springtime low-level mixed-phase clouds over the Greenland and Norwegian Seas.

(initial title was: **Characterization of Arctic mixed-phase cloud properties at 1 small scale and coupling with satellite remote sensing**.)

By G. Mioche et al.

The authors would like to thank the reviewer for his/her helpful comments and suggestions, which hopefully will help us to greatly improve the quality of our paper.
Below you will find detailed answers to the reviewer's comments:

- **the reviewer's comments (RC) are reported in bold**,
- *the authors' responses (AR) are reported in italic,*
- *the changes in the revised manuscript are indicated in italic and red color.*

All the manuscript has been rewritten, title has been modified and numerous additions and changes concerning the structure have been made in order to take into account the reviewer's comments. For this reason, the whole additional text included in the revised manuscript could not be indicated in this document.

In regards to the major comments made by reviewer 2 and to keep focus in the paper, the part dealing with satellite remote sensing validation (section 5, figures 12, 13 and 14 and tables 4, 5, 6, and 7) has been removed and will be the topic of a future paper.

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1)
(page 5 line 189 and appendix B)
Referee comment (RC): I am a little unhappy about the dismissal of the effect of shattering on the probes. I understand that this is difficult with older probes but surely the CPI would have provided inter arrival time information and possibly visual evidence of shattering – this would then add weight to the comparison of the extinction coefficients in appendix B. Also were the clouds heated – I don't think this is mentioned.
Authors' response (AR): The CPI used is the version 1. It has a maximum image capacity of 40 images per seconds, thus the maximum time resolution between two images (i.e. the maximum inter-arrival time resolution) is 25ms. Measurements from ***Korolev et al. (2013)*** *made with the NRC Convair-580 in similar flight conditions show on figure 14 that the inter-arrival times of shattered particles are below 1 ms. The CPI cannot produce evidence of shattering thanks to the particle arrival time. Visual evidence of shattering is difficult (at best) has shown by* ***Schwarzenboeck et al. (2009)****.*
All the cloud probes were heated to avoid icing during the flights.

2)
(page 5 line 195)
RC: Was the air temperature probe heated and what type of probe was used? A heavily iced probe can have a large influence on the air temperature.
AR: The types of probes used are:

- *Rosemount sensor during the POLARCAT and ASTAR campaigns,*

- *and the Advanced Airborne MeasureMent Solutions system (AIMMS-20) during the SORPIC campaign.*

All the air temperature probes were heated to avoid icing during the flights. This has been added line 204.

3)
(Page 6 line 219)
RC: Surely there are only 5 normalised levels in the cloud?
AR: We used 5 normalized levels to have statistically representative levels. More than 5 levels in the cloud layer can lead to some level with a very weak number of observations and thus averaged profiles not really representative.

4)
(Page 8 line 278.)
RC: It would be interesting to compare the LWC values in clouds with that obtained with an adiabatic ascent from the cloud base – this would give further confidence in the observed LWC values.
AR: It has been done based on the calculation of the ratio of observed LWC values on the adiabatic LWC values in figure 7 and discussed in the text. It gives an indication on the efficiency of ice processes (WBF, riming), as well as evaporation of liquid droplets at cloud top.

5)
(page 9 line 323 ..)
RC: It would be interesting to see how the habit (and the number) of
the ice crystals observed varied with temperature as well as with height.
AR: It is done in the panels c) and d) in Figure 5 (now Figure 6 in the revised manuscript).

6)
RC: I am surprized at the lack of needles reported – there appear to be clouds warmer than -10 degC where I would expect the Hallet Mossop process to be important and at these temperatures I would expect there to be columns present (see Lloyd et all ACP15 p. 3719-3737)
AR: Ice shape depends on the temperature when ice nucleation occurs, and this temperature can be different of that of in situ observations. This could explained that needles are not observed above -10°C. Moreover, there are few data corresponding to temperatures warmer than -10°C.

7)
(page 13 line 503 and figure 9b)
RC: And why does figure 9b show no ice above -10deg C. I feel that this apparent absence of secondary ice at warmer temperature should be discussed – if only briefly.
AR: IWP is very small above -10°C, but is not equal to 0. Moreover, Figure 9b (now Figure 10b in the revised manuscript) displays IWP according to the cloud top temperature (i.e. the coldest temperature for each profile) and very few profiles have a cloud top temperature above -10°C.

8)
(page 15 line 579 onwards)
RC: I think comparison between the satellite data and the observations is very useful. However I would have liked more description of the DARDAR scheme and how retrievals method used to determine cloud phase differs between the satellite and in situ measurements. Are the two retrieval methods looking at different things.

*AR: Detailed description of DARDAR scheme is made in **Ceccaldi et al. (2013)**, and **Delanoë and Hogan (2008, 2010)**, but section 5 has been removed and will be the topic of a separate paper.*

9)
(Page 17 line 655)
RC: I cannot really see the pink in figure 13
AR: Figure 13 has been removed since section 5 has been removed.

References

Ceccaldi, M., Delanoë, J., Hogan, R. J., Pounder, N. L., Protat, A. and Pelon, J.: From CloudSat-CALIPSO to EarthCare: Evolution of the DARDAR cloud classification and its comparison to airborne radar-lidar observations, J. Geophys. Res. Atmospheres, 118, 1–20, doi:10.1002/jgrd.50579, 2013.

Delanoë, J. and Hogan, R. J.: A variational scheme for retrieving ice cloud properties from combined radar, lidar, and infrared radiometer, J. Geophys. Res., 113(D07204), doi:10.1029/2007JD009000, 2008.

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Schwarzenboeck, A., Shcherbakov, V., Lefevre, R., Gayet, J.-F., Pointin, Y. and Duroure, C.: Indications for stellar-crystal fragmentation in Arctic clouds, Atmospheric Res., 92(2), 220–228, doi:10.1016/j.atmosres.2008.10.002, 2009.