Reply to Referee # 2

The authors thank the reviewer for his pertinent and helpful comments on the paper and they are grateful for his review which is always rather time-consuming and cumbersome. The manuscript has been modified according to the suggestions proposed by the reviewer. The remainder is devoted to the specific response item-by-item of the reviewer's comments :

Major Comments :

1. Grammar/writing : Of course all the corrections kindly pointed out by the reviewer have been made in the revised version of the manuscript. Furthermore the manuscript has been reviewed by a English-native person.

2. The main results obtained during previous observations in mixed-phase Arctic clouds are now referenced in the introduction with a discussion about the modeling studies on ice formation mechanisms published in the last years.

3. Estimation of the fresh water accumulation over the Greenland sea pool: We have evidenced that ice crystals precipitate down to the sea surface from observations and pictures taken onboard the aircraft when flying at the lowest level (~500m a.s.l., see Figure B1). This feature is confirmed from AMALi lidar observations performed during the first part of the flight above the cloud (see section 2.3). Fig. B2 represents the corresponding time series profile of (a) back scattering and (b) depolarization ratio. The results show that occasionally when the cloud layer was enough transparent (from 09:00 to 09:03 for example), there is a clear signature of ice crystals down to the see level with moderate backscatter values and enhanced depolarization. It should be noticed this feature in mixed-phase clouds in the Arctic was also often observed during POLARCAT (2008) experiment in Northern region of Norway.

Concerning the error estimate on IWC measurements from PMS 2D and CPI instruments they were evaluated to 100% (Gayet et al., 2002). The precipitation rate (R) is calculated from the following relationship (see Heymsfield and Parrish, 1979):

$$R \propto \sum_{j,D} V_{j,D} \, M_{j,D}$$

With : $V_{j,D}$: the terminal velocity of particle with habit (j) and size (D) (see relationships from Heymsfield, 1972) and $M_{j,D}$ the mass of particles with habit (j), size (D) and concentration ($N_{j,D}$).

Considering uncertainties of 30% and 100% on V and M respectively, the subsequent 'root-sum-square' (RSS) errors of these uncertainty contributions are resulting in precipitation rate uncertainty of about 110%.

Minor comments :

1. See revised version.

2. On Fig. 10 the x-axis (LWC / IWC) is represented in log scale and the examination of measured values of LWC (red points) and LWC (black) near the cloud top show much larger LWC values than IWC ones.

3. and 4. See revised version.

5. The reviewer is right; ice crystals are not always non-spherical. Nevertheless, frozen cloud droplets do not remain perfectly spherical due to internal structure strengths during freezing. Sensitivity studies on the Polar Nephelometer response have shown that even a slight deviation from the spherical shape does result in variation of the scattering phase function that could be measured (see discussion in Febvre et al., JGR, 2009.).

6. During the flights performed during ASTAR 2007 campaign in mixed-phase clouds, moderate icing was observed with maximum LWC values up to 0.4 g/m3 even for cloud top temperature down to -23°C. The probe de-icing systems worked properly and no icing effect on the data quality was observed.

7. and 8. See revised version.

9. The aircraft trajectory was prepared in accordance with the Air Traffic Control Authority before the flight with way point locations and flight levels. During the Flight on 9 April the way points were defining according to the Satellite overpass prediction.

During the data processing, in order to reduce inherent errors in comparing quasi-instantaneous spaceborne observations and aircraft measurements carried out during a much longer duration, the flight trajectory was corrected. The method consisted to project the flight path onto the CALIPSO/CloudSat vertical plane by considering the mean wind advection at the corresponding levels and the time difference between satellite and in situ measurements.

10. See revised version.

11. The question about the smallest ice crystals that can be detected from remote sensing is pertinent. Unfortunately we do not have reliable information on the minimum size detected from (spaceborne) radar observations at 94 Ghz (this is an open question).

12. The reviewer is right; too much ice concentration is reported. In fact after checking our data the ice particle concentration is much lower (max. ~ 50 l-1, see new Fig. 4.a). However this value could be overestimated by effects of shattering of large ice crystals observed in this area.

13. The software developed at LaMP (Lefèvre, 2007) allows to categorize water drop spherical particles and graupels based on surface roundness and roughness criteria (no water droplets are observed on Fig. 5 because there are too small (d<100 μm) to be classified).

14. See revised version.

15. In principle it is not possible that there is more ice in the juicer clouds resulting to higher depolarization values. Figure B3 (same plot as Fig. 6) illustrates results we obtained during the CIRCLE2 campaign (Gayet et al., CALPSO Science Team meeting, Madison, WI, July 28-31, 2009). These results concern the observation by CALIOP of a thin cirrus cloud (visible optical depth of 0.5) with a stratocumulus (liquid water) below. On Fig. 3 the water layer is characterized by a positive relationship between the attenuated backscatter (γ') and depolarization ratio (δ) as observed for the Arctic mixed-phase cloud on 9 April. The randomly (or irregularly shaped) ice particles in the cirrus are mostly observed with a negative γ'- δ relationship with much lower γ' values, whereas oriented particle (mostly plate ice crystals) in the cirrus are found with high γ' and low δ values. This feature is in accordance with the theoretical results from Hu et al. (2007, Optic Express) and was nicely confirmed from in situ measurements (Mioche et al., 2009, JGR CALIPSO special issue, submitted).

16. and 17. See revised version.

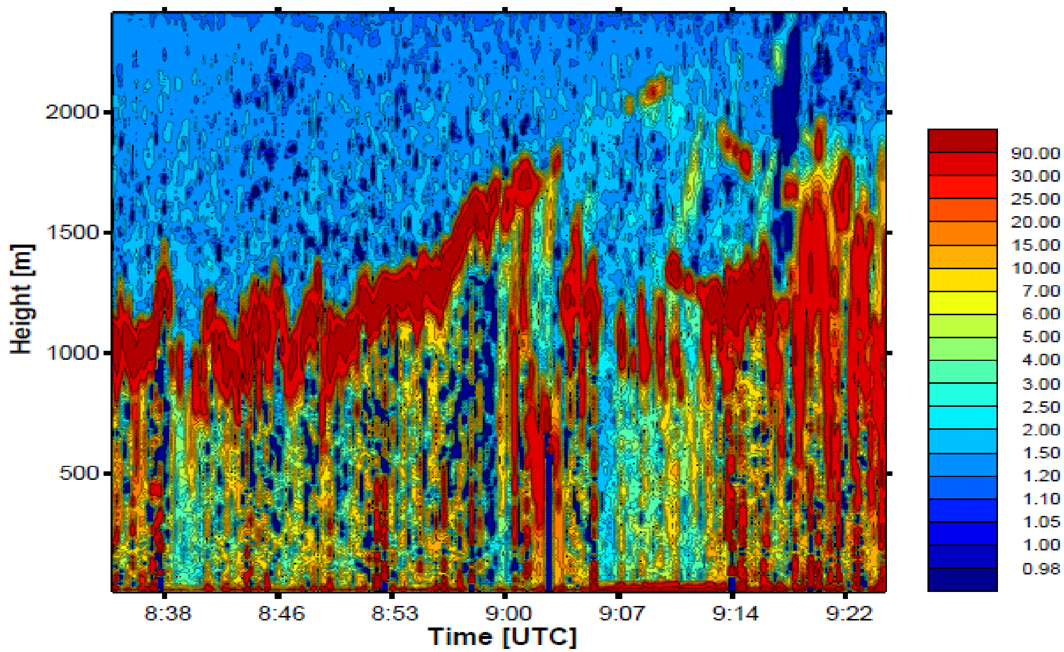
18. See previous discussion above (point # 3).

19. See revised version.

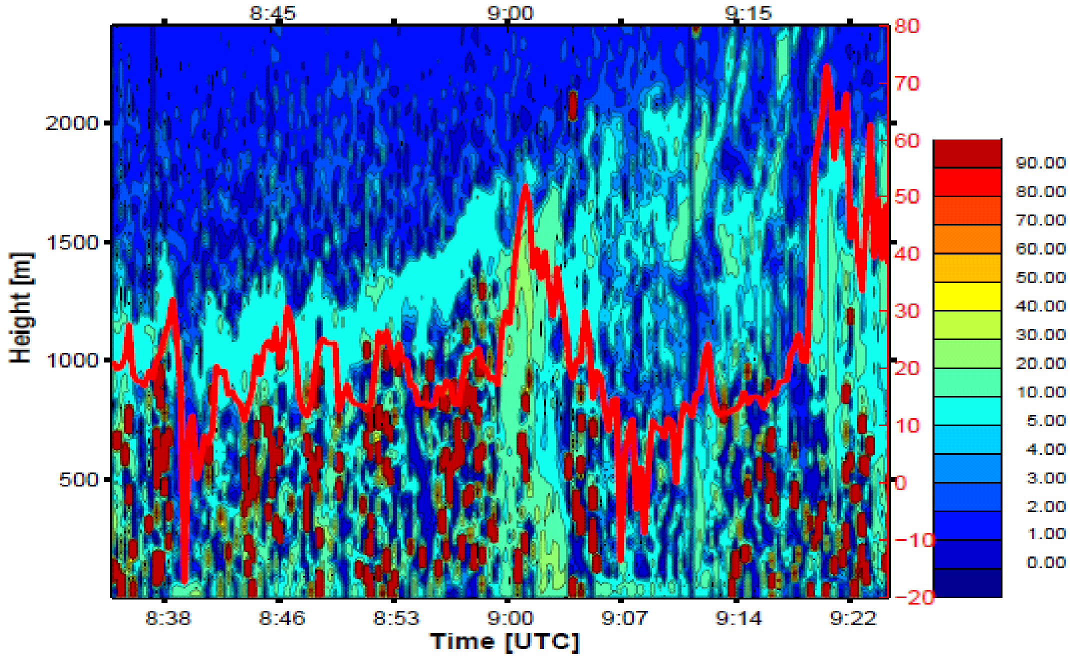
20. Same as point # 18.

21. and 22. See revised version.

Figure B1

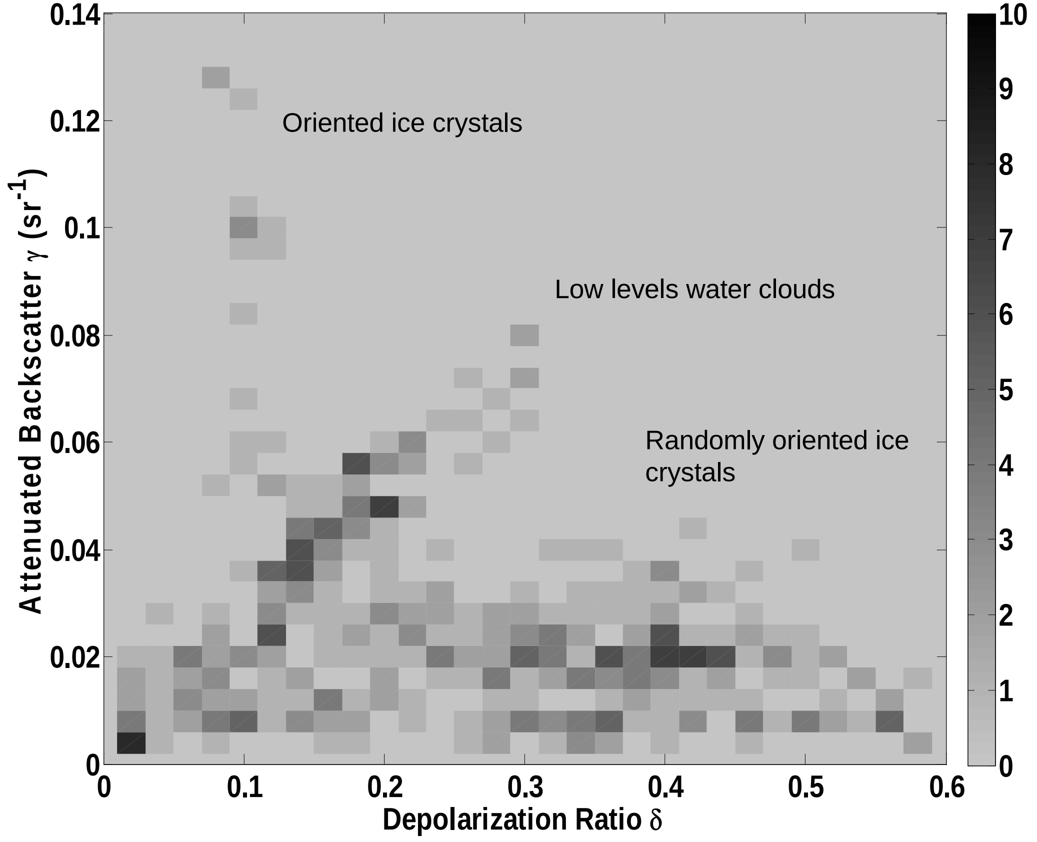


(a) AMALi airborne lidar backscatter profiles on 9 April 2007.



(b) AMALi airborne depolarization profiles on 9 April 2007.

Figure B2 (Courtesy by A. Lampert)



Oriented ice crystals
Low levels water clouds
Randomly oriented ice crystals
Attenuated Backscatter γ (sr-1)
Depolarization Ratio δ
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.1
0.2
0.3
0.4
0.5
0.6
10
9
8
7
6
5
4
3
2
1

Figure B3