Comparisons between CloudSat products and in situ observations
Part II : Mixed-phase cloud characterization

G. Mioche(1), J-F Gayet (1), A. Herber(2), A. Schwarzenboeck(1), J. Pelon(3) and A. Protat(3)

[1] LaMP CNRS / Université Blaise Pascal, Aubière, France, [2] AWI, Bremerhaven, Germany, [3] LATMOS CNRS / Université Pierre et Marie Curie, Paris, France

In order to validate new space remote sensing observations (CALIOP on CALIPSO and CPR on CloudSat) validation plans took place including in situ measurements co-located with the satellite along-tracks. In this context, the ASTAR and POLARCAT airborne campaigns were carried out respectively in Arctic regions near Spitzbergen in April 2007 and in Northern part of Sweden in April 2008 to experience mixed-phase clouds by using AWI Polar2 and SAFIRE ATR42 aircraft respectively. The main objectives of these field projects were the characterization of microphysical and optical properties of mixed-phase and ice clouds with particular interest on the validation of clouds products derived from CloudSat and CALIPSO data during co-located spaceborne remote sensing data along with detailed in situ microphysical observations. The airborne microphysical instruments included the Polar Nephelometer probe, the high resolution Cloud Particle Imager (CPI) and standard PMS 2D and FSSP-100 instruments. Part II of the poster illustrates results obtained on 9 April 2007 in the Western part of Spitzbergen during quasi co-located observations carried out in boundary layer mixed-phase cloud with cloud top levels ranged between -24°C and -21°C. The retrieved equivalent reflectivities and microphysical cloud parameters (*IWC, R_{eff}* and particle concentration) from CloudSat algorithms are discussed with in situ observations.

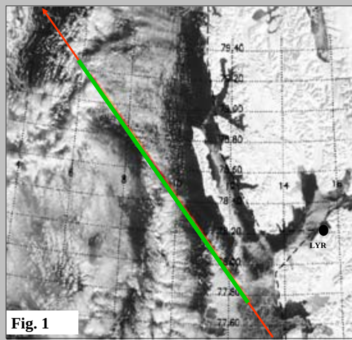

Fig. 1

Fig. 1 display MODIS visible channel at 10:06 UTC along with CALIPSO CloudSat overpass (red curve) and the Polar-2 flight trajectory (green). Vertical profiles of the attenuated backscatter CALIOP signal and CloudSat reflectivity along with the Polar2 flight altitudes are displayed on Figs. 2 and 3 respectively. Figs. 4 and 5 represent the values of cloud microphysical parameters obtained during the aircraft ascent-descent sequences. Strong backscatter coefficients from CALIOP near the cloud top indicates a liquid water layer. This feature is confirmed by in situ data on Fig. 4, i.e. asymmetry parameter (*g*) > 0.8, *LWC* up to 0.3 g/m3 and D_{eff} ~ 10-20 µm. CloudSat reflectivities with echo core up to 15 dBZ (Fig. 3) are due to large ice crystals (*g* < 0.8) with sizes up to 2 mm and ice water (0.15 g/m3, see Fig. 5). Ice particles are yielded within the liquid water layer.

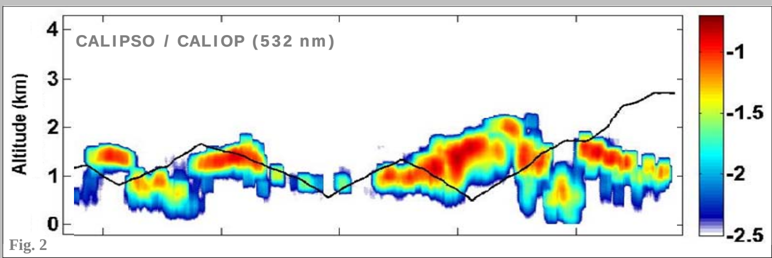

Fig. 2

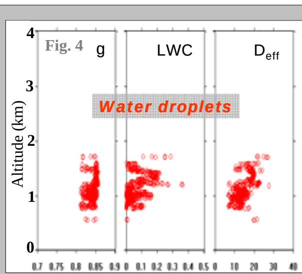

Fig. 4

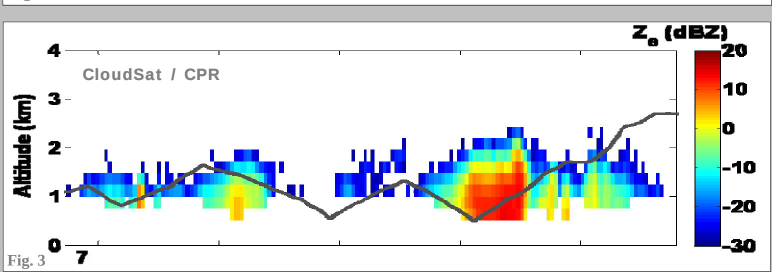

Fig. 3

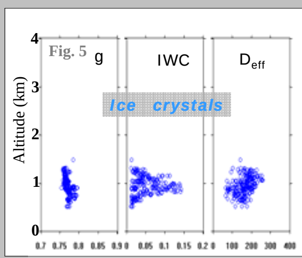

Fig. 5

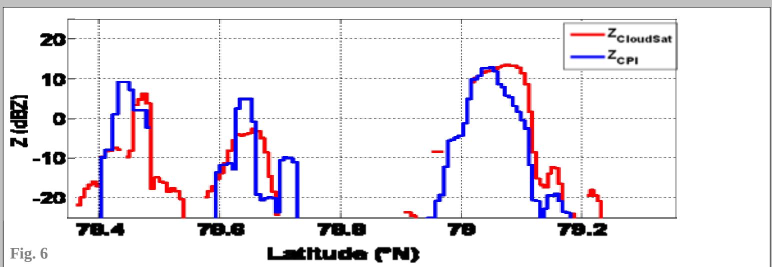

Fig. 6

The comparisons of reflectivity factors between CloudSat (CPR) and in situ measurements (CPI) along the flight trajectory are reported on Fig. 6. In situ measurements are averaged over the CPR horizontal resolution (~1.7 km). The time separation between CPR and CPI is within ± 20 mn. CloudSat and in situ reflectivities fit rather well (slope parameter of 0.95, see Fig. 7) although a poor correlation (R^2 =0.62) due to a large scatter of data.

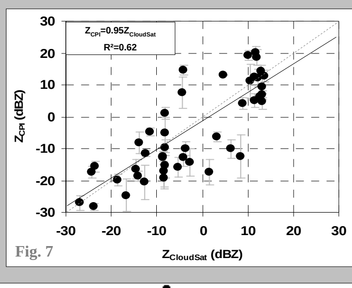

Fig. 7

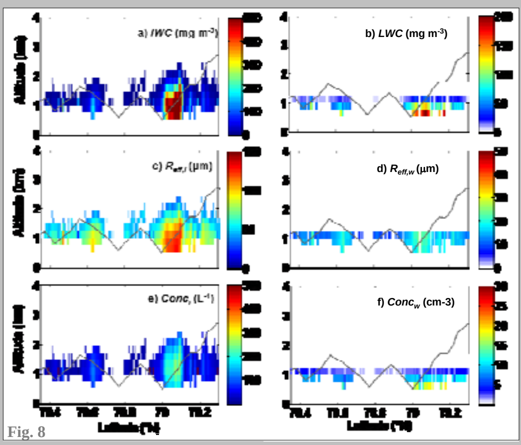

Fig. 8

Fig. 8 displays the vertical profiles of the retrieved microphysical cloud parameters from CloudSat retrievals in terms of ice and liquid phases respectively: Ice / Liquid water content (*IWC/LWC*), effective radius (R_{eff}) and particle concentration (*Conc*). Note no liquid water is retrieved above 1.3 km (T<-20°C). Comparisons between remote (CloudSat) and in situ values are reported on Fig. 9. As for cirrus cloud (see part I of this poster) *IWC* from CloudSat are overestimated with regards to in situ observations. For the others cloud parameters the results show that no reliable relationships can be proposed for both water phases due to uncorrelated parameters (R^2 < 0.26).

The reliabilities of the results are hampered by :

- The variability of cloud properties during time duration of quasi co-located observations (± 20 mn);

- The uncertainties on cloud microphysical parameter derivation (instruments & mass-size relationships), ΔZ = ±4 dBZ, ΔIWC ~60%, $\Delta\sigma$ ~ 55%, ΔD_{eff} ~ 80%;

- A inadequate parameterization of *LWC/IWC* partitioning (versus temperature) for Arctic boundary layer mixed-phase clouds.

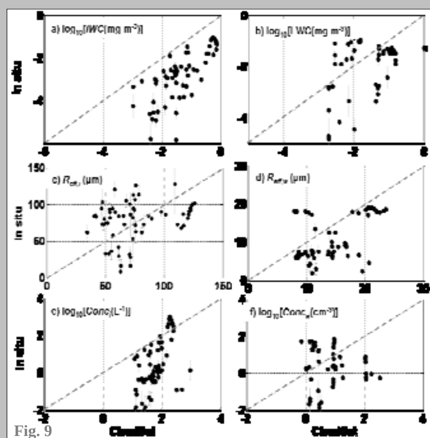

Fig. 9

Acknowledgements. This work was funded by CNES, IPEV and a grant from CNRS/INSU. AWI contributed to a large part of Polar 2 flight hours. Thanks are due to the members of AWI, Optimare and DLR (ASTAR) and SAFIRE (POLARCAT) who organized the experiment management and aircraft operations. We acknowledge NASA Langley Research Atmospheric Science Data Center, as well as ICARE Center in Lille for the CALIPSO data. We acknowledge C. Gourbeyre, and J-F Fournol (LaMP), Thomas Garbrecht, and Jürgen Höltig (Optimare) and SAFIRE team for their active participation to the experiments.

Laboratoire de Météorologie Physique
http://wwwobs.univ-bpclermont.fr/atmos

CNRS INSU Institut national des sciences de l'Univers
Université Blaise Pascal
OPGC Observatoire de Physique du Globe de Clermont-Ferrand