Ground based in situ measurements of arctic cloud microphysical and optical properties at Mount Zeppelin (Ny-Alesund, Svalbard) : Preliminary results

G.GUYOT[1], O.JOURDAN[1], F.OLOFSON[1], V.SHCHERBAKOV[1], P.TUNVED[2], C.GOURBEYRE[1], G.FEVBRE[1], R.DUPUY[1], C.BERNARD[1], G.ANCELLET[3], K.LAW[3], A.SCHWARZENBOECK[1]

[1] Laboratoire de Météorologie Physique, LaMP, Université Blaise Pascal (UBP), OPGC, CNRS UMR 6016, Clermont-Ferrand
[2] Department of Applied Environmental Science (ITM), Stockholm University, Stockholm, Sweden
[3] Laboratoire Atmosphère, Milieux et Observations Spatiales, LATMOS, IPSL, UPMC, CNRS UMR 8190, Paris

1.Context

The high sensitivity of the polar region to the global climate warming, due to singular feedbacks existing in this region, was shown by many studies [IPCC,2007]. In particular, climate simulations suggest that cloud effects play an important role in arctic warming [Hassol, 2005]. Moreover, high seasonal variability in aerosol properties was measured in the Arctic by [Engwall et al., 2008; Tunveld et al., 2012]. In consequence, changes in cloud properties are expected during the winter\summer transition but are not well understood yet. Consistent efforts are thus made nowadays to improve our knowledge of the temporal variation of the cloud geometrical, optical and microphysical properties, especially for low level stratiform clouds.

Within the CLIMSLIP (Climate impacts of short-lived pollutants and methane in the Arctic) project, a set of ground-based cloud measurements was performed in Mt Zeppelin, in Ny-Alesund, Svalbard, by the LaMP between 6 March and 2nd May 2012. The weather conditions allowed us to study five cases of mixed phase low level clouds, three cases of snow precipitations and two cases of blowing snow. In addition, aerosols measurements are continuously monitored at the Zeppelin station by ITM. This allows us to study the variability of the microphysical and optical properties of low level clouds as well as the aerosol-cloud interaction.

2.Ground-based instrumentation

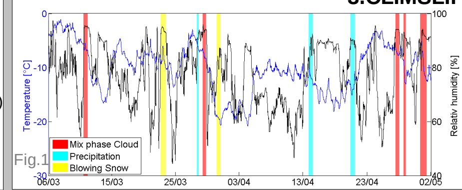
- **Cloud properties**

Cloud Particle Imager (CPI) [15µm – 2.5mm]
Nevzorov probe : hotwire probe; IWC, LWC
Forward Scattering Spectrometer Probe (FSSP) [3 – 45 µm]
Polar Nephelometer [3 – 800µm] : phase function (at λ=0.8 µm)

- **Aerosol properties**

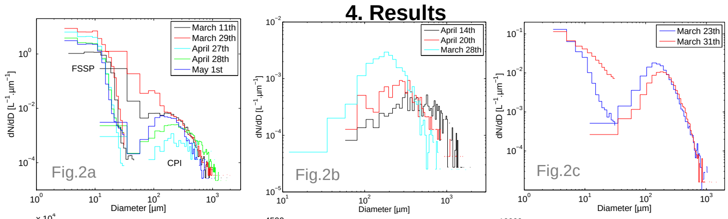
Condensation particle counter (CPC) [10nm – 3µm]
Differential Mobility Particle Sizer (DMPS) [25 – 800 nm]

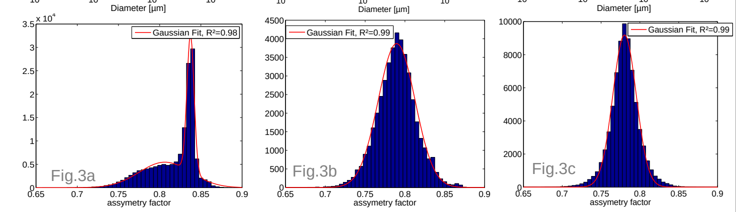
3.CLIMSLIP-NyA campaign



- Fig.1 displays an overview of the cloud measurements during the CLIMSLIP campaign. The temperature and the relative humidity measured at the Zeppelin station are plotted. Mixed phase clouds (MPC), precipitation and blowing snow (BS) episodes are shown by red, cyan and yellow zones, respectively. The MPC episodes are related to peaks of the relative humidity and were observed between -5 and -12 ℃.

4. Results





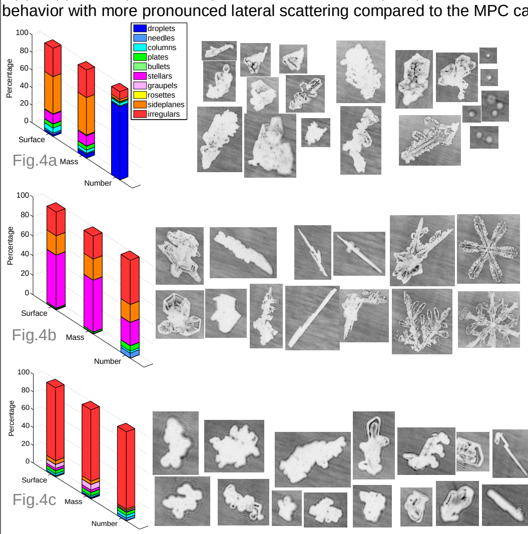
- Fig.2 a, b and c display the size distribution, measured by CPI and FSSP of cloud particles.
- (a) MPC cases reveal different processes of particle formation :

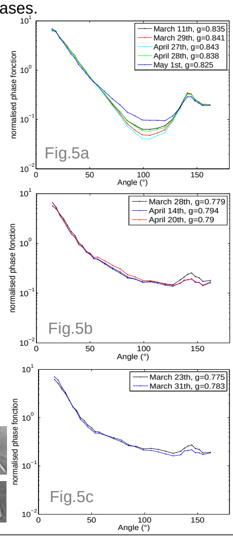
-Bimodal distribution (27 April, 28 April and 1st May). This could reveal a growth by riming/aggregation.

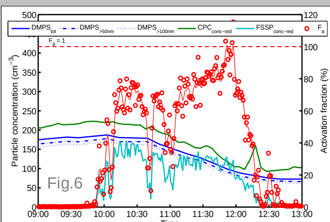
-Power law distribution (11 March and 29 March), which could be due to a growth by Bergeron effect with strong interaction between droplets and crystals.

- (b) Precipitations cases : lower concentration and more variability compared to the MPC cases. However, the 28 March case show a different size distribution than 14 and 20 March, due to a warmer temperature (-5℃ instead of -12℃ on the fig.1).
- (c) Blowing snow cases are characterized by a bimodal distribution. The PSD measured by the FSSP can be attributed to the presence of small ice crystals.
- Fig.3 a, b and c show histograms of the asymmetry factor g, derived by the Polar Nephelometer. Each histogram was fitted by Gaussian curves with a very good correlation.
- (a) two modes for the MPC cases, with a mean value of 0.83 for water droplets.
- (b) & (c) one mode for the precipitations and the BS episodes, with a mean value for ice crystals around 0.78. The mean values are in agreement with the typical values.

- Fig.4 a, b and c display the shape classification (performed manually) of the cloud particles measured by the CPI. Some examples of cloud particles imaged by the CPI are plotted on the right side of Fig.4.
- (a) MPC cases : Number concentration dominated by droplets whereas side plane are the prevailing shape considering surface and mass
- (b) & (c) cloud particle area dominated by stellars for the precipitation cases, and large dominance of irregular particles for the BS cases.
- Fig.5 a, b and c represent the mean phase function measured by the Polar Nephelometer.
- (a) MPC cases : phase functions characterized by substantial scattering at forward and backward angles. The discrepancies in the lateral region (60 – 120°) can be linked to variations of liquid water fraction.
- (b) & (c) : as expected, the phase functions for the precipitations and the BS cases exhibit a featureless behavior with more pronounced lateral scattering compared to the MPC cases.







- Fig.6 is an example (29 March) of aerosol measurements (DMPS and CPC) combined with cloud measurements (FSSP). This allows us to deduce the activation fraction in red, which is included between 60 and 100% with an aerosol concentration ranged between 100 and 220 cm^{-3}. The DMPS data show a small quantity of aerosols with a size less than 100 nm.
- Those analysis of the MPC cases have to be compared to the back trajectories of the air masses, which could explain the aerosols concentration evolution and properties.

5. Conclusion

In the context of accelerated warming in the arctic region, this study focuses on the properties of clouds. We show the first results of the CLIMSLIP campaign performed by the LaMP in Mount Zeppelin, Ny-Alesund, Svalbard from 6 March to 2nd May 2012 using ground-based instrumentation. The measurements show three different cloud episodes : the MPC, the precipitation and the BS cases. The distribution show some differences between the MPC cases which are probably characteristics of different growth processes. The asymmetry parameter shows also a type Gaussian curve. A ice morphological characterization was performed for the three cases. Finally, the phase functions show stronger lateral scattering for the precipitations and the BS cases. The future work will focus on the aerosol measurements and retroplumes to study the aerosol/cloud interactions.

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