Mixed-phase Arctic cloud studies: EPOPEE / ASTAR 2004 + 2007

EPOPEE: Etude de la Phase glace dans l'interaction des propriétés OPtiques Et microphysiques des nuages mixtes En Arctique

ASTAR: Arctic Study of Tropospheric Aerosols, Clouds, and Radiation

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In-situ studies of Artic mixed-phase clouds during EPOPEE / ASTAR 2004

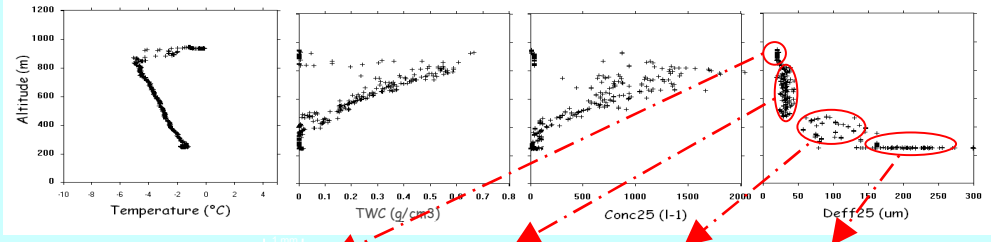
CLOUD INSTRUMENTATION ONBOARD POLAR-2 AIRCRAFT:

1. Polar Nephelometer :
Scattering phase function of cloud particles
(3 µm < D < 1 mm)

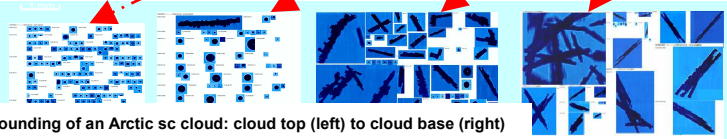
2. Cloud Particle imager (CPI) :
High resolution measurement of particle shape
(2.3 µm pixel size)

3. Nevzorov probe (AWI) :
Liquid (LWC) and ice water content (IWC)

4. PMS FSSP-100 & 2D-C probe :
Size distribution (and shape) of cloud particles (3µm < D < 800µm)

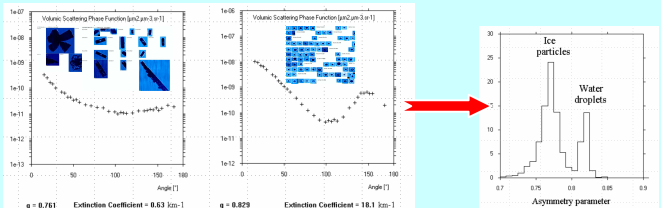


Cloud microphysics



Vertical sounding of an Arctic sc cloud: cloud top (left) to cloud base (right)

Cloud optics



Scattering volume phase function, extinction coefficient and asymmetry factor (histogram)

RESULTS ASTAR-2004

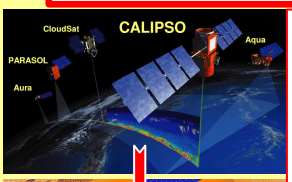
➡14 cloud in situ flights (ns, sc, as)

- ➡ In-cloud temperatures: -18°C < T < -2°C
- ➡ Most clouds at least mixed-phase clouds
- ➡ Clouds form in clean air masses (N=300cm^{-3}) with few IN, CCN: Arctic as a cloud laboratory
- ➡ Ice nucleation more linked to temperature threshold than to aerosol properties

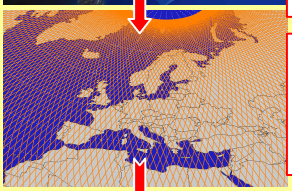
- ➡ Drizzle observed in numerous stratiform clouds (even for thin cloud layers), biggest drops (500 µm) near cloud base.
- ➡ Cloud ice nucleation with heterogeneous liquid/ice signatures and precipitating crystals (also clear sky precipitation)

- ➡ Ice multiplication processes active but slowed down: e.g. crystal fragmentation
- ➡ Mixed-phase clouds often topped by liquid water (active mixing process) - no ice signature from space remote observations.
- ➡ Shortcomings in satellite retrievals.

Outlook: Validation of CALIPSO/CLOUDSAT satellite derived cloud products during ASTAR 2007



Aqua-Train:
CLOUDSAT (Radar 95 GHz)
CALIPSO (Lidar 532 ⊥ & ll / 1064 nm and IIR 8.7, 10.5, 12.0 µm)
AQUA (Modis radiometer)
PARASOL (Polder)

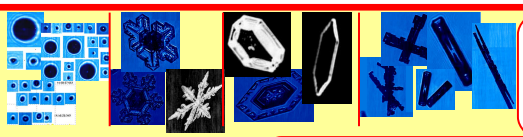


16 day repeat cycle produces a grid spaced by e.g. 172 km at the equator:

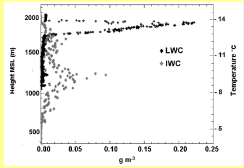
⇨ Svalbard will be a perfect validation site!

Cloud Data Product	Data Product Resolution Horizontal	Vertical
Height	1/3, 1, 5 km	30, 60 m
Thickness	1/3, 1, 5 km	30, 60 m
Cloud classification	N/A	N/A
Ice particle size	1 km	N/A
Ice/water phase	5 km	60 m
LWC, IWC	N/A	N/A
Backscatter, $\beta_c(z)$	5 km	60 m
Extinction, $\alpha_c(z)$	5 km	60 m
Optical depth, τ	5 km	N/A
Ice cloud transmissivity, ε	1 km	N/A
Reflectivity	N/A	N/A
Radiative flux and heating rate	N/A	N/A

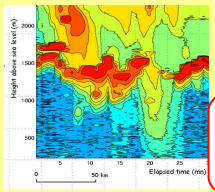
CALIPSO and CLOUDSAT retrieved cloud products: Validation based on groundbased remote sensing as well as in situ measurement instrumentation!

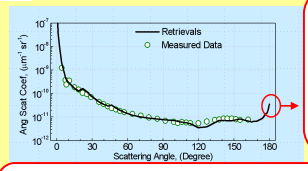


CPI, FSSP, 2D-C: Vertical profiles of cloud particle phase and size measured directly by in situ probes



Nevzorov Probe [also in situ cloud particle probes CPI etc.]:
Vertical profiles of condensed water contents LWC, IWC





Polar Nephelometer:
Profiles of optical parameters retrieved from scattering phase function (Jourdan et al., 2003) :
Extinction/backscatter ratio at 532 / 1064 nm (⇨lidar)

AMALi lidar on Polar-2 aircraft:
Backscatter coeff. $\beta_{cloud}(z)$; extinction coeff. $\sigma_{cloud}(z)$;
lidar depolarisation ratio and cloud particle phase!

ACKNOWLEDGEMENTS: We would like to thank AWI for the overall logistic and financial support of the French participation onboard the Polar 2 aircraft. This work is co-financed by the French 'Institut Polaire Paul Emile Victor' (IPEV) and the INSU / PATOM Committee.