In situ observations and retrieval results of an A380 contrail

(a case study)

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CNRS INSU Observer & comprendre — Université Blaise Pascal Clermont-Ferrand — OPGC Observatoire de Physique du Globe de Clermont-Ferrand


CONCERT *CONtrail and Cirrus ExpeRimenT*
From 20 October to 21 November 2008
The main objective is the detection of microphysical, chemical and radiative properties of contails and natural cirrus clouds to allow for a better estimate of their impact on climate.
Aircraft: German Falcon operated by DLR

Motivation:

● Single-scattering parameters of ice and mixed-phase clouds are of importance for radiative transfer calculations in climate models.
The knowledge of these parameters is the prior condition for the interpretation of cloud remote-sensing data.

● Complex shapes of ice crystals and subtle interactions between microphysical-morphological and optical properties of particles make difficult the accurate assessment of single-scattering parameters.

● Direct observations of optical properties and morphologies of ice crystals along with the adapted modeling could improve the parameterization of ice and mixed-phase clouds.

The cloud *in situ* measurements AIRBORNE PLATFORM

(the DLR Falcon aircraft during CIRCLE-2 experiment)

- **Cloud Particle imager (CPI)** : High resolution measurement of the cloud particle shape (2.3 µm pixel size, D > 100 µm).
- **Polar Nephelometer (PN) :** Measurement of the scattering phase function of cloud particles (3 µm < D < ~ 1 mm).
- **PMS FSSP-300 and 2D-C probes** : Particle size distribution (and shape) of particles (1 µm < D < 1 mm).

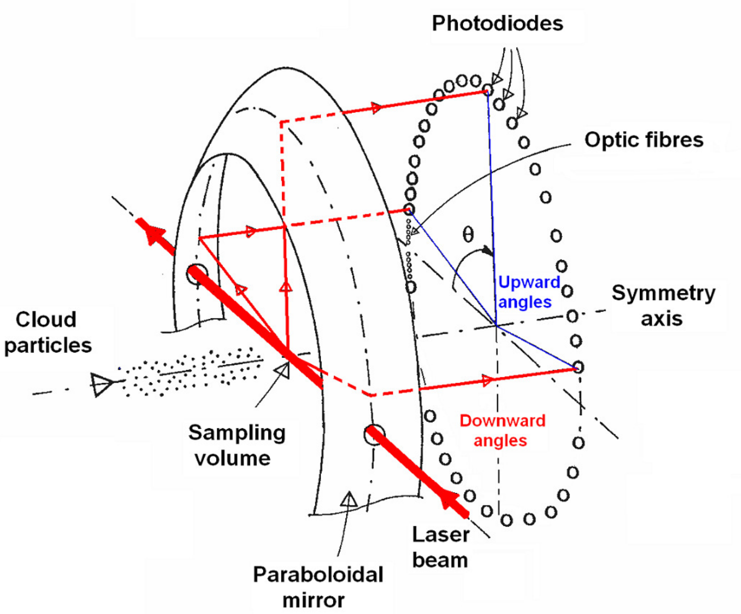
AIRBORNE PLATFORM

(derivation of microphysical and optical parameters)

- **Ice particle concentration (d > 1 μm) : FSSP + 2D-C**
- **Ice particle concentration (d > 25 μm) : 2D-C**
- **Extinction coefficient : - FSSP + 2D-C**
  - Polar Nephelometer
- **Ice Water Content : FSSP + 2D-C *(assume size – mass relationship or ice density)***
- **Effective diameter (∝ IWC / Ext) : FSSP + 2D-C**
- **Asymmetry parameter : Polar Nephelometer**
- **Pristine crystal classification (22° Halo) : Polar Nephelometer**
- **Particle shape classification (d > 100 μm) : 2D-S or CPI**

2D-C → 2D-S or CPI

Polar Nephelometer

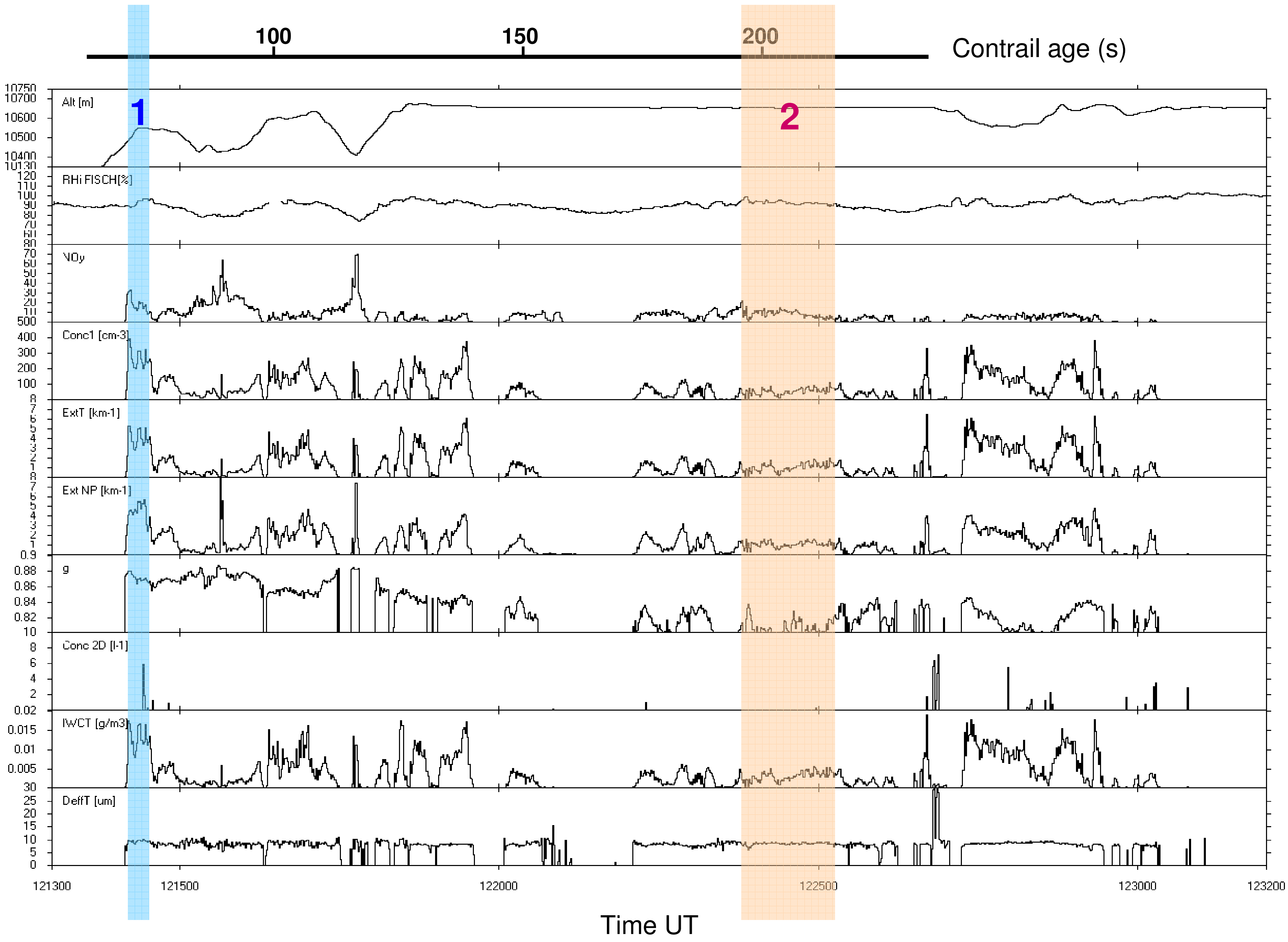


Laser diode : P = 1W ; λ = 800 nm
Laser beam diameter .... 5 mm
Inlet diameter .... 10 mm
Sensitive volume 0.2 cm3
Sampling volume at 100 m/s................ 5 L / sec.

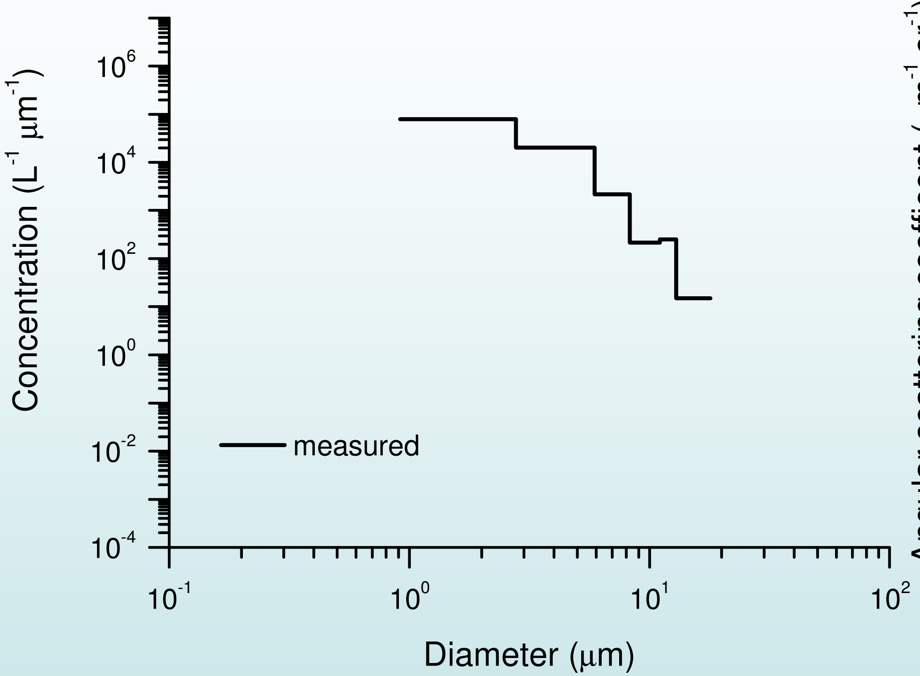
4 measurements from **5.9°** to **10.6°**; resolution : **1.58°** (Upward)
31 measurements from **15.0°** to **169.0°**; resolution : **7.0°** (Upward : 22) (Downward : 9)

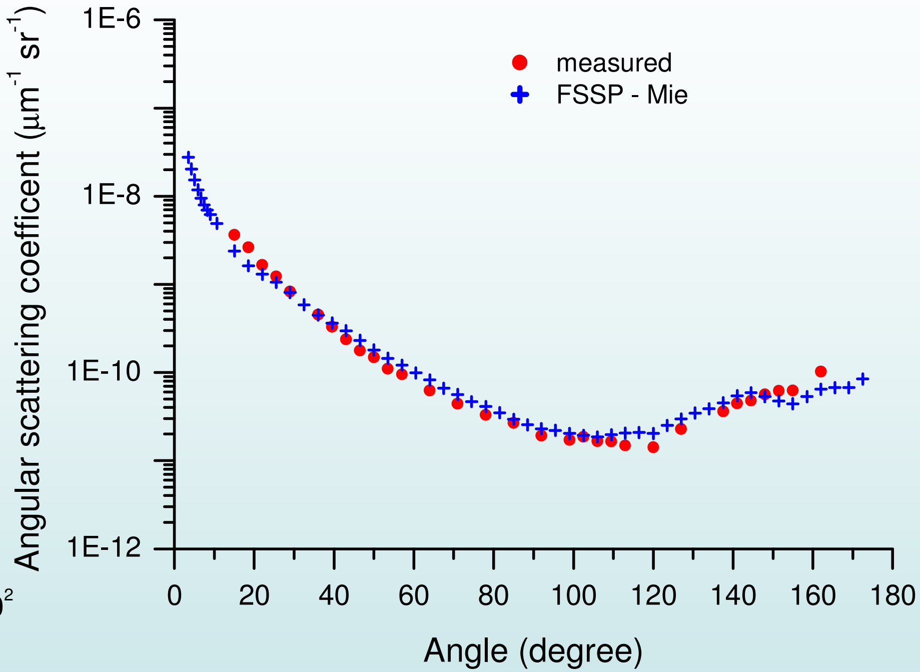
Total : **35** angles of measurements (can be increased up to 54)

(from Gayet et al., 1997)


Contrail age (s)
100
150
200
1
2
Alt [m]
RHi FISCH[%]
NOy
Conc1 [cm-3]
ExtT [km-1]
Ext NP [km-1]
g
Conc 2D [l-1]
IWCT [g/m3]
DeffT [um]
121300
121500
122000
122500
123000
123200
Time UT

1 - Contrail age ~ 80 sec. (12:14:05 – 12:14:21 UT)



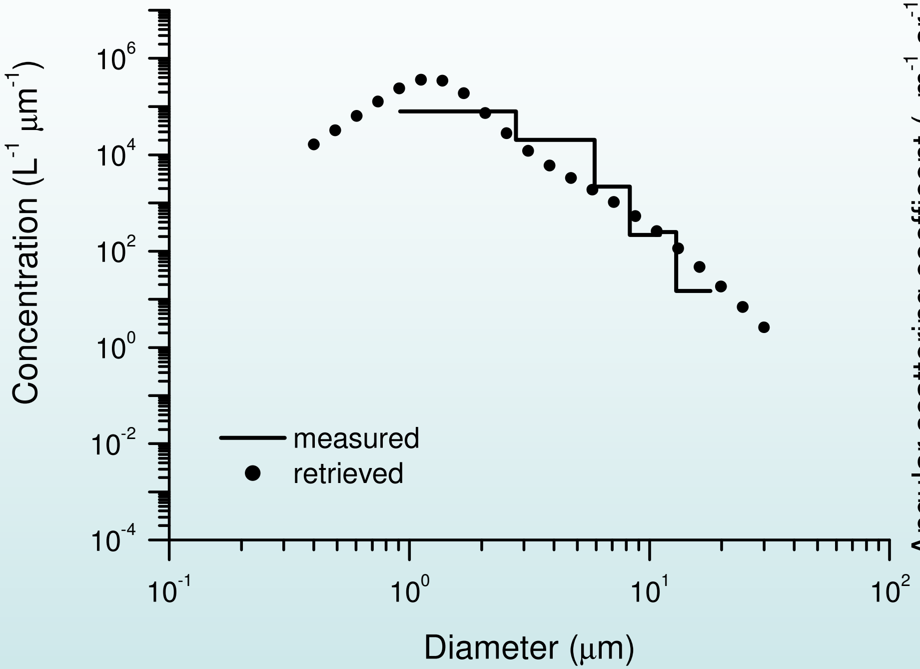


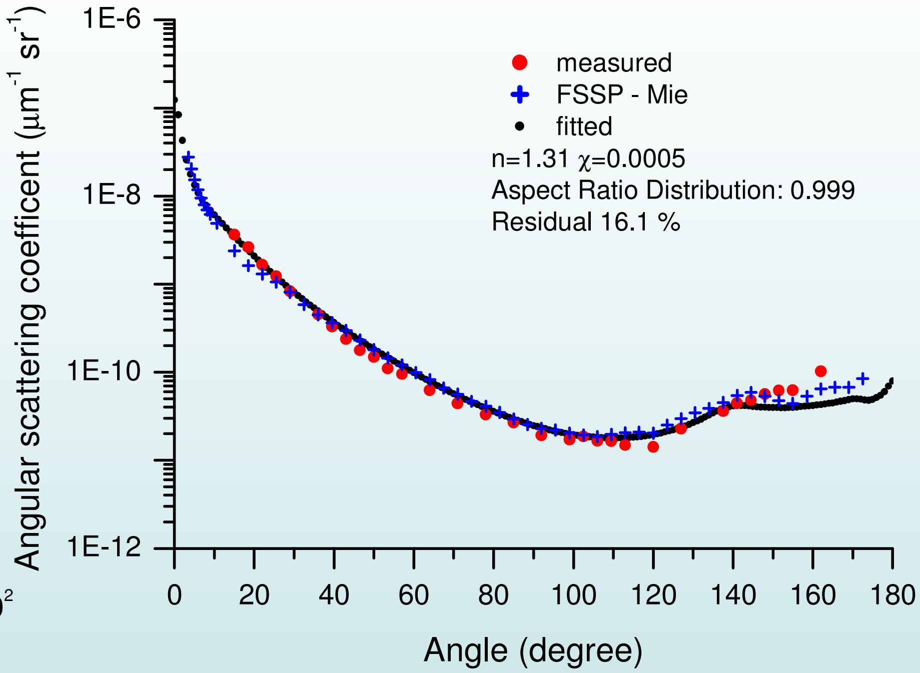
Alt :	10536 m	Temp. :	-54.5 °C	RHi :	91 %
NOy :	17.1 nmol/mol	IWC :	4.5 mg/m3	Deff :	3.5 µm

Ext_{NP}. : 3.50 km^{-1} g_{NP} : 0.873

1 - Contrail age ~ 80 sec. (12:14:05 – 12:14:21 UT)

Dubovik et al. (JGR 2006) code retrievals



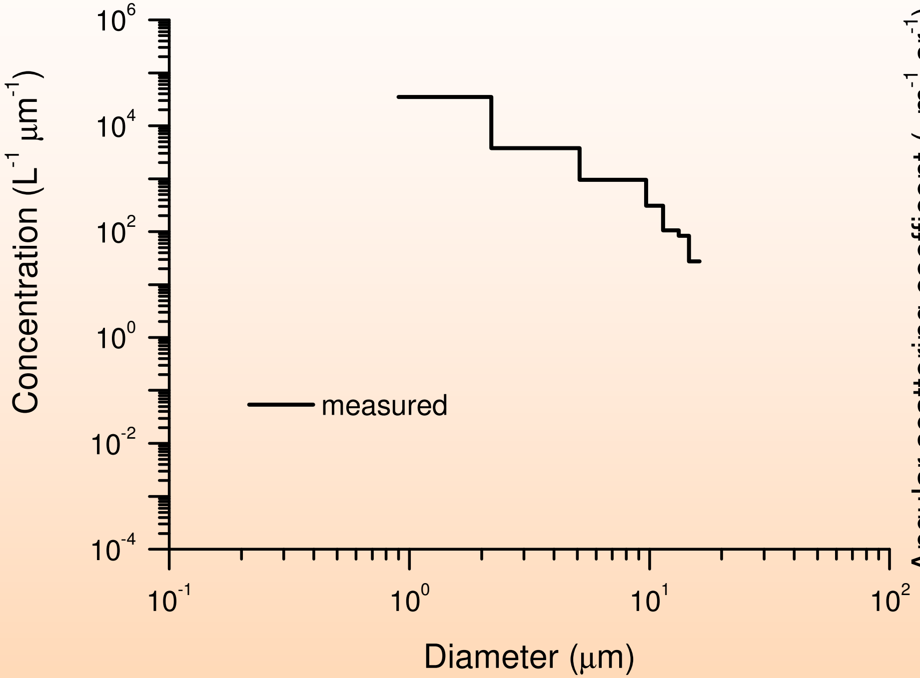


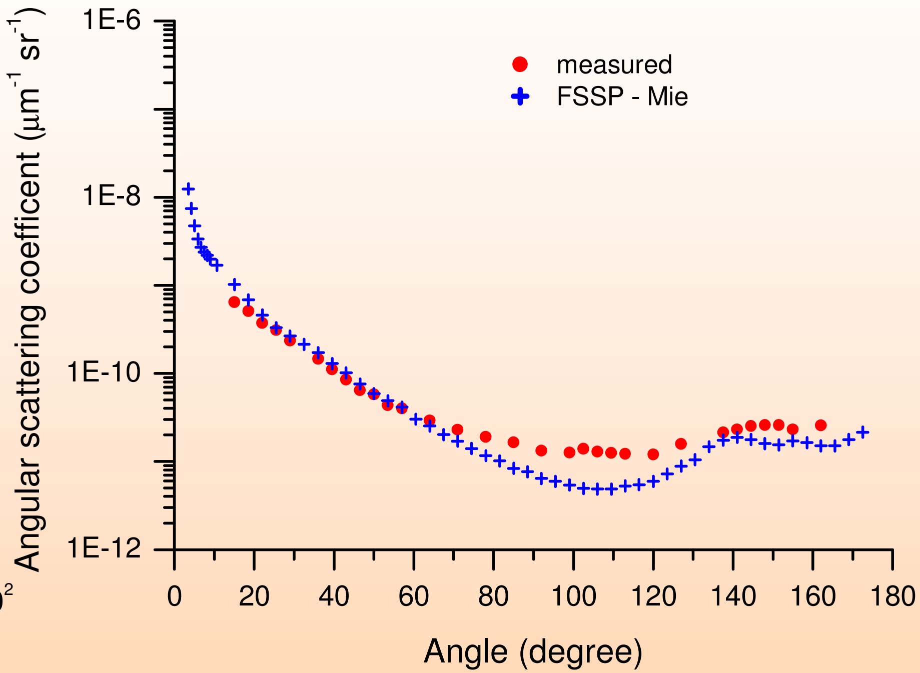
Alt :	10536 m	Temp. :	-54.5 ℃	RHi :	91 %
NOy :	17.1 nmol/mol	IWC :	4.5 mg/m3	Deff :	3.5 µm

Ext_{NP}. : 3.50 km^{-1} g_{NP} : 0.873

$Ext_{retrieval}$: 3.07 km^{-1} $g_{retrieval}$: 0.835

2 - Contrail age ~ 200 sec. (12:23:48 – 12:25:09 UT)



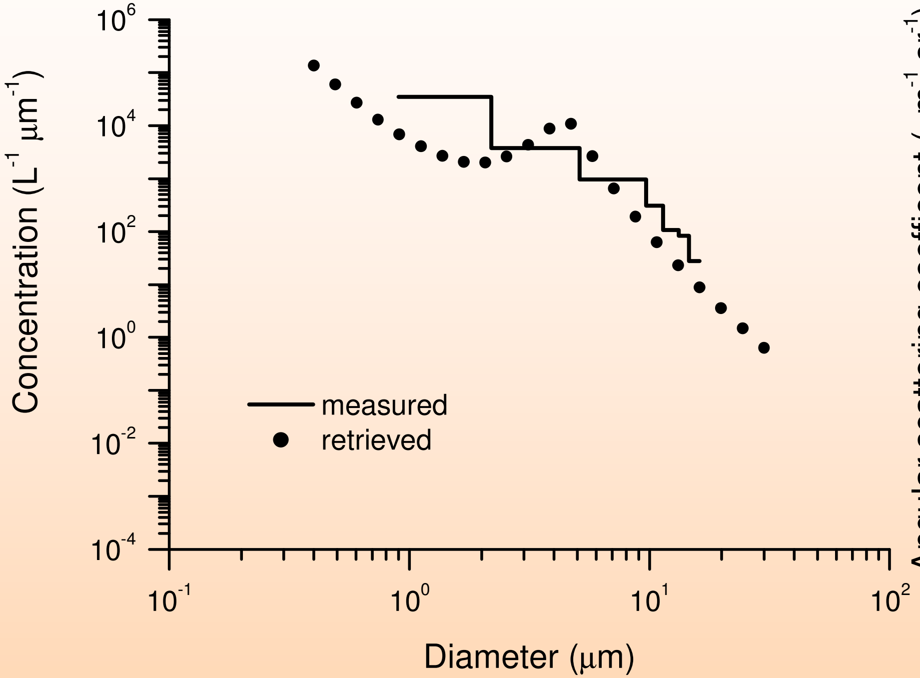


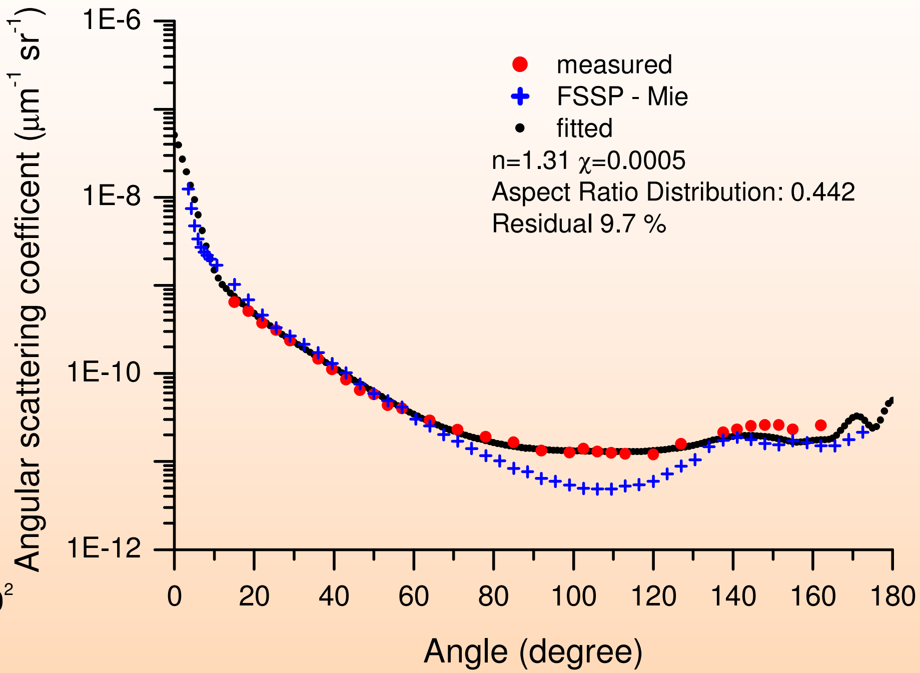
Alt :	10651 m	Temp. :	-56.8 ℃	RHi :	93 %
NOy :	8.5 nmol/mol	IWC :	1.8 mg/m3	Deff :	4.8 µm

Ext_{NP}. : 1.08 km^{-1} g_{NP} : 0.805

2 - Contrail age ~ 200 sec. (12:23:48 – 12:25:09 UT)

Dubovik et al. (JGR 2006) code retrievals





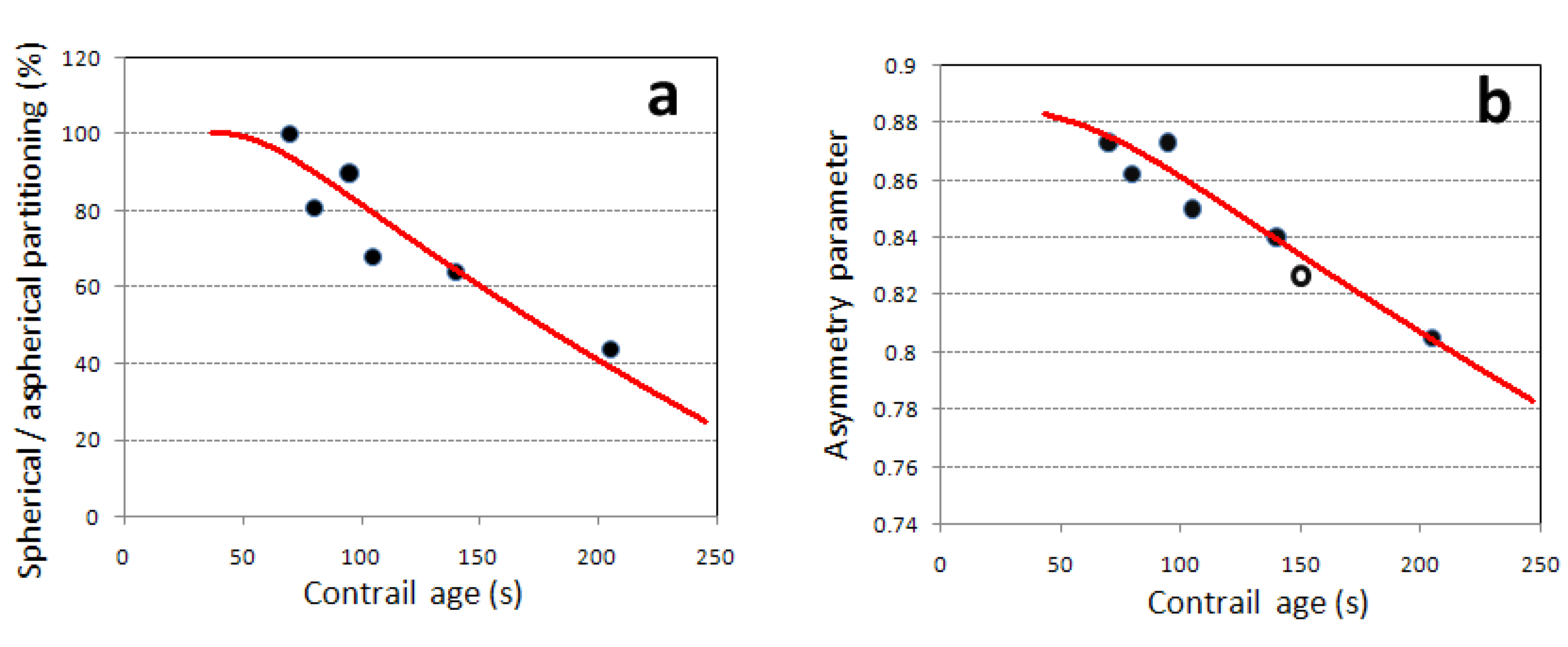
Alt : 10651 m   Temp. : -56.8 ℃   RHi : 93 %

NOy : 8.5 nmol/mol   IWC : 1.8 mg/m3   Deff : 4.8 µm

Ext_{NP}. : 1.08 km^{-1} g_{NP} : 0.805

$Ext_{retrieval}$: 1.15 km^{-1} $g_{retrieval}$: 0.812

Partitioning ratio and asymmetry parameter versus the contrail age



CONCLUSIONS

- **Spherical ice particles were observed in the 80 seconds aged contrail.**

- **Partitioning ratio and asymmetry parameter decrease with the contrail age .**

- **The phase functions of spherical and <u>nonspherical</u> particles are quit well fitted by spheroid models** *(Dubovik et al., JGR, 2006)***.**

LONG-TERM PROSPECTS

The LaMP (laboratory of the physical meteorology) participated (e.g., CALIPSO mission) **and will participate in numerous national and international projects devoted to *in situ* validation of remote-sensing data.**

Satellite remote-sensing:

- ► POLDER/PARASOL (LOA);
- ► EarthCare (European Space Agency's cloud & aerosol mission);
- ► **…**

Airborne remote sensing:

- ► RALI (RAdar - LIdar) (IPSL/CETP);
- ► SMART Albedometer (Leibniz-Institut for Tropospheric Research, Leipzig);
- ► **…**