LOAC (Light Optical Aerosol Counter)

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Light Optical Aerosols Counter

Project funded by the French National Research Agency (ANR)

Collaboration between a national research laboratory (LPC2E), private companies (Environnement-SA, MeteoModem, Aerophile SAS), and the French Space Agency (CNES)

130 copies produced at the end of 2017

More than 100 scientific flights under different kinds of balloons at the end of 2017

Instrument and pump: 300 g

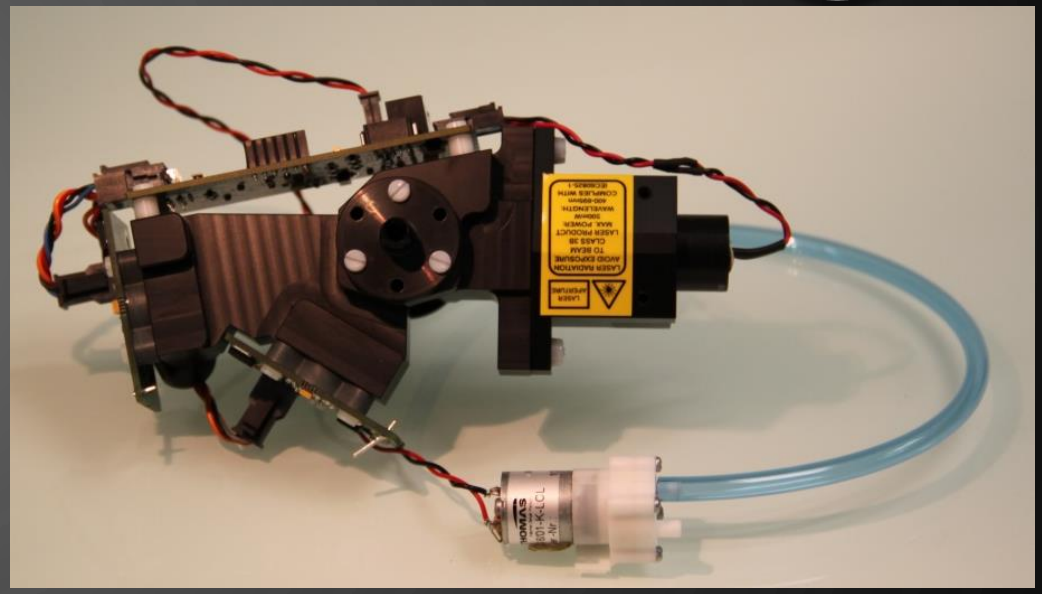
Electric consumption: ~3 W

No lenses => no risk of misalignment

Concentrations for 19 size classes between 0.2 and 100 µm

Automatic check every 10 minutes and electronic recalibration if necessary (ex. strong changes in ambient temperature)

Total weigh (gondola, batteries and LOAC): 1 kg for use with weather balloons



Principle of measurements

Measurements at 2 scattering angles (field of view of few degrees)

~12°, insensitive to the refractive index of the particles (mainly diffraction)

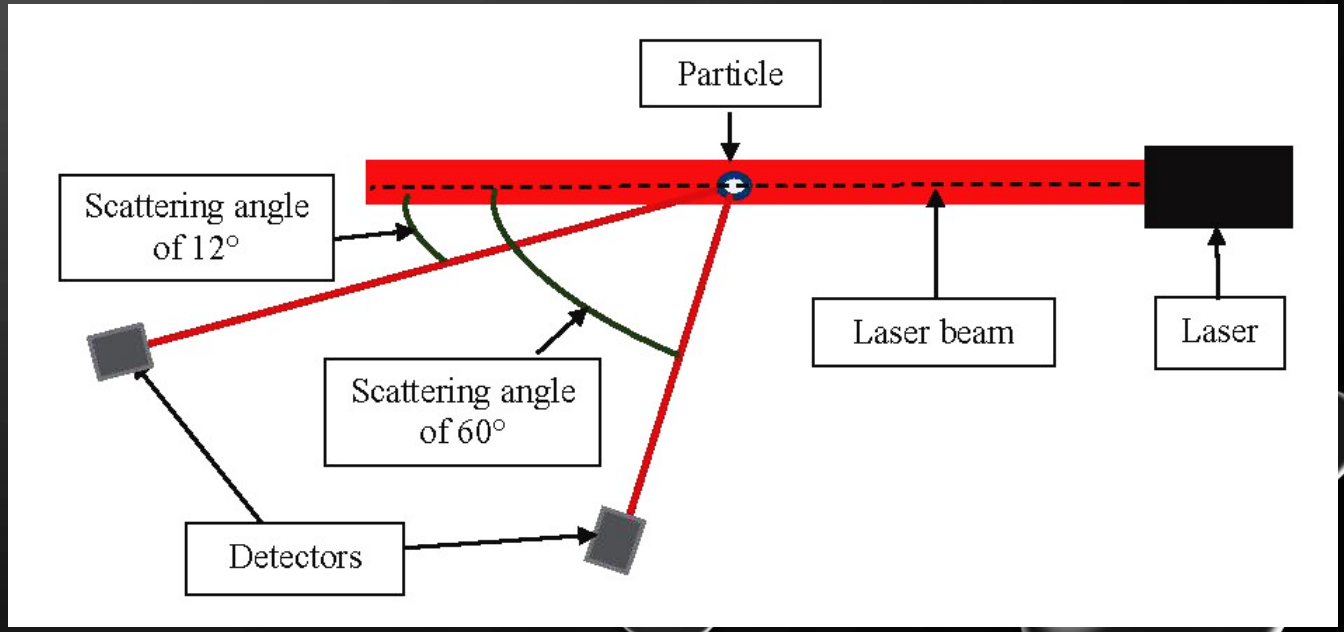
=> accurate size determination and counting

~60°, strongly sensitive to the refractive index of the particles

=> indication of the typology of the particles

Detection of the maximum of intensity for particle that crosses the laser beam

Real-time stray light correction

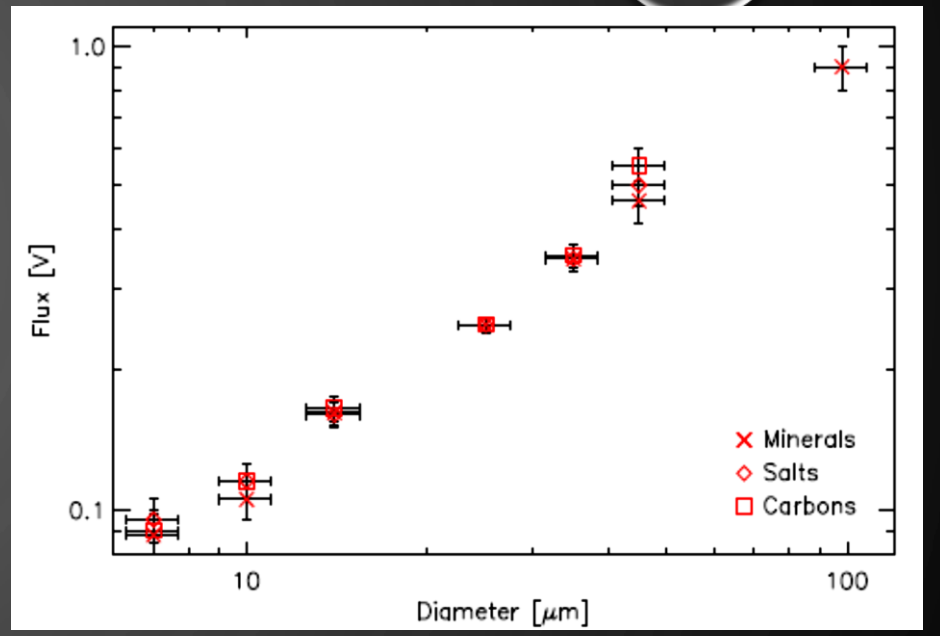


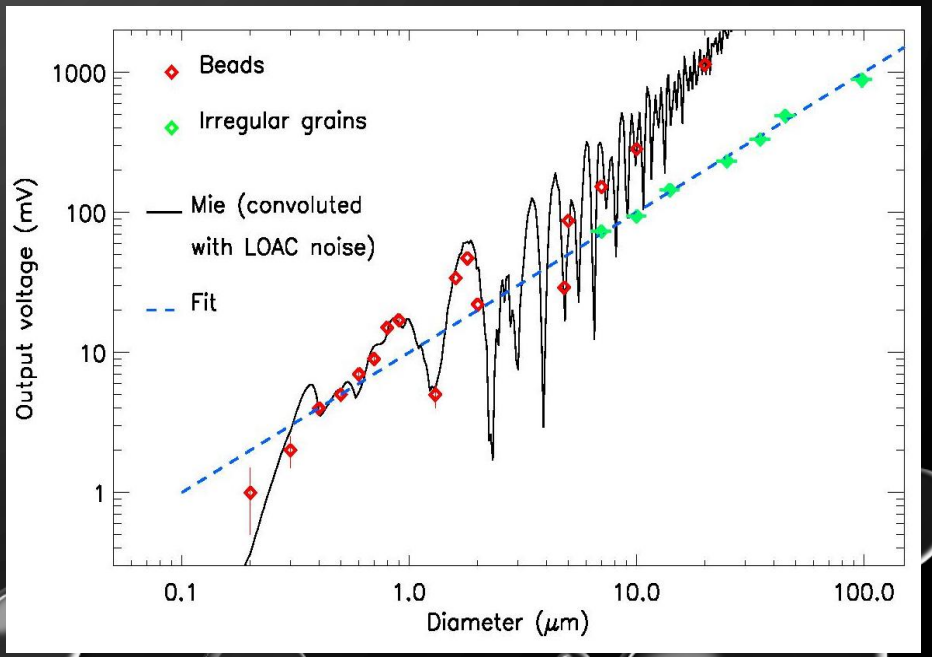
Calibrated with beads and real irregular particles

Similar statistical approach for the detection of irregular particles (“natural solid particles”)

At a given diameter, same scattered flux for different natures of particles (at small scattering angles)

LOAC can be used for liquid and irregular particles but not for perfect solid spheres





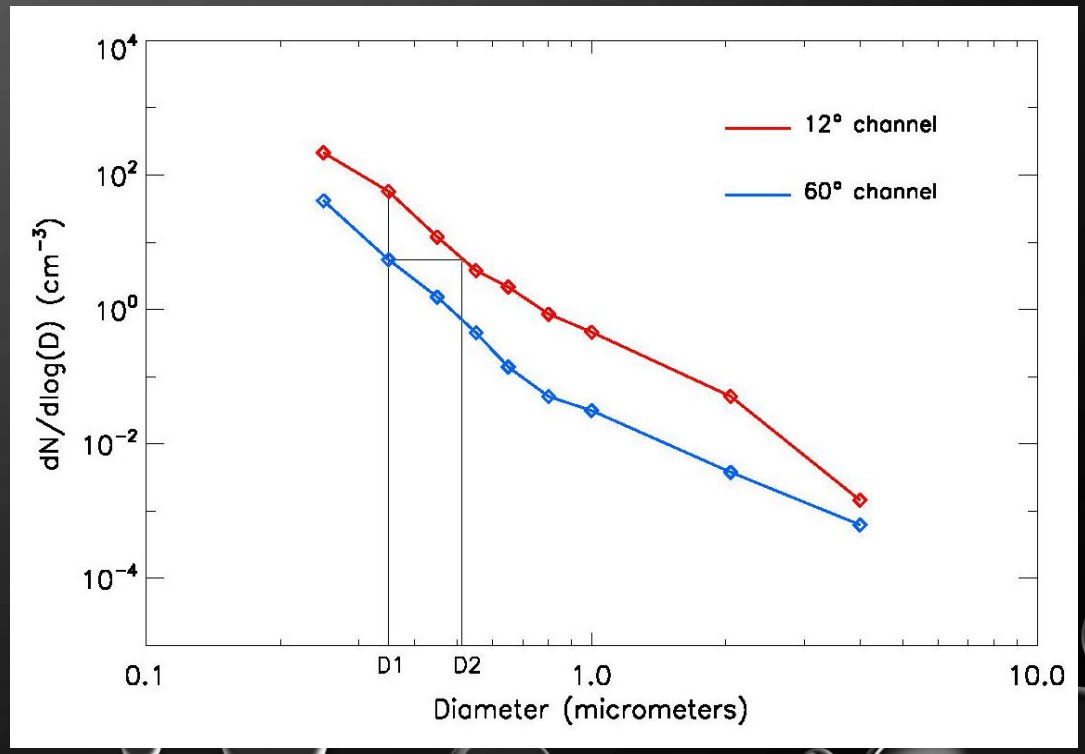
Determination of the main nature of the particles: Typology

The 60° measurements are very sensitive to the refractive index of the particles

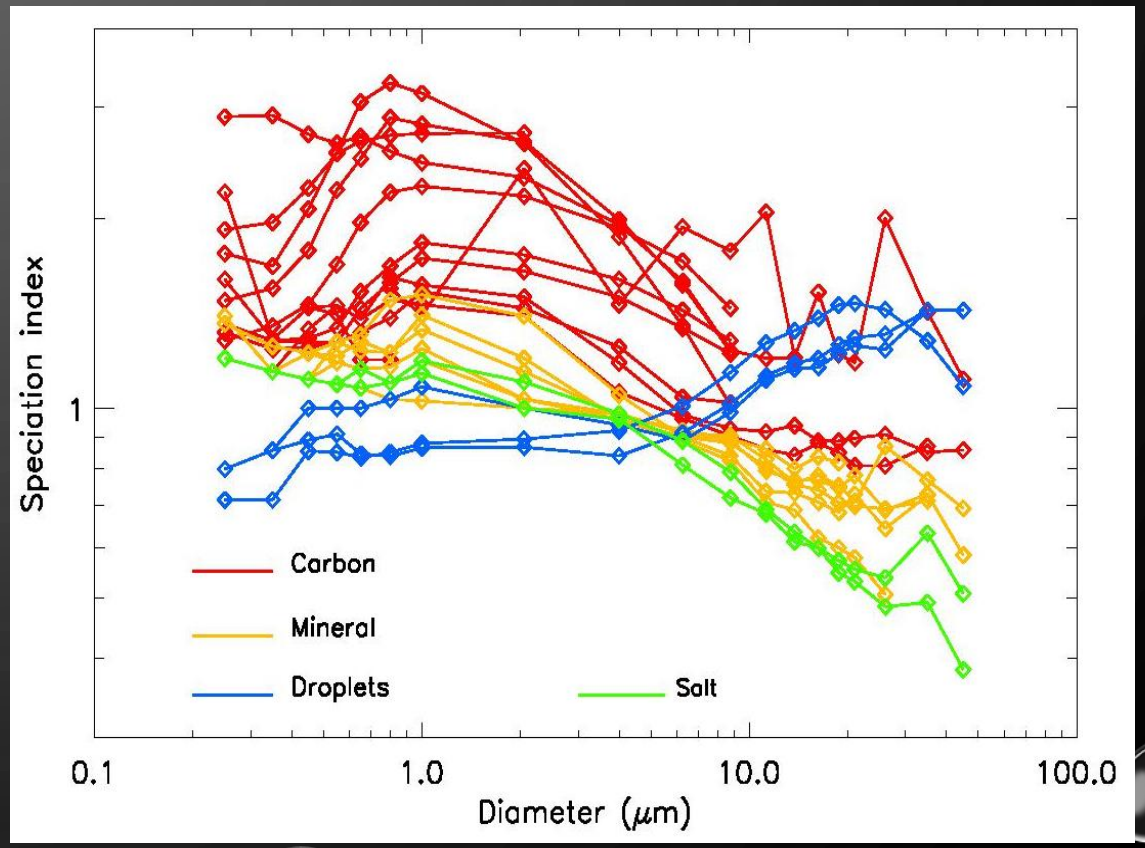
More absorbing are the particles, lower is the scattered flux

⇒ The 60° size distribution is often lower than the 12° real size distribution

The ratio of the 2 size distributions varies with the nature of the particles

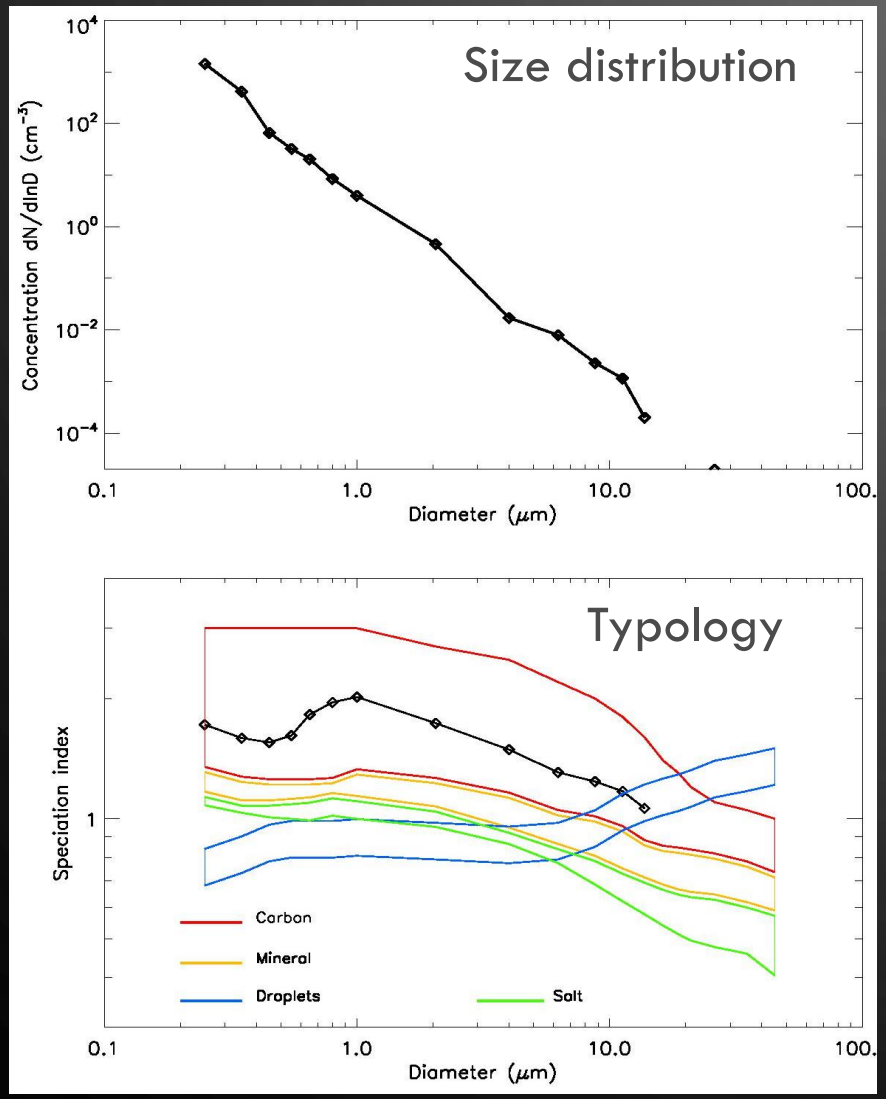


- **The 12°/60° ratio (“speciation index”) is compared to charts obtained in laboratory for different families of particles:**
  - Liquid droplets
  - Minerals
  - Salts
  - Carbonaceous

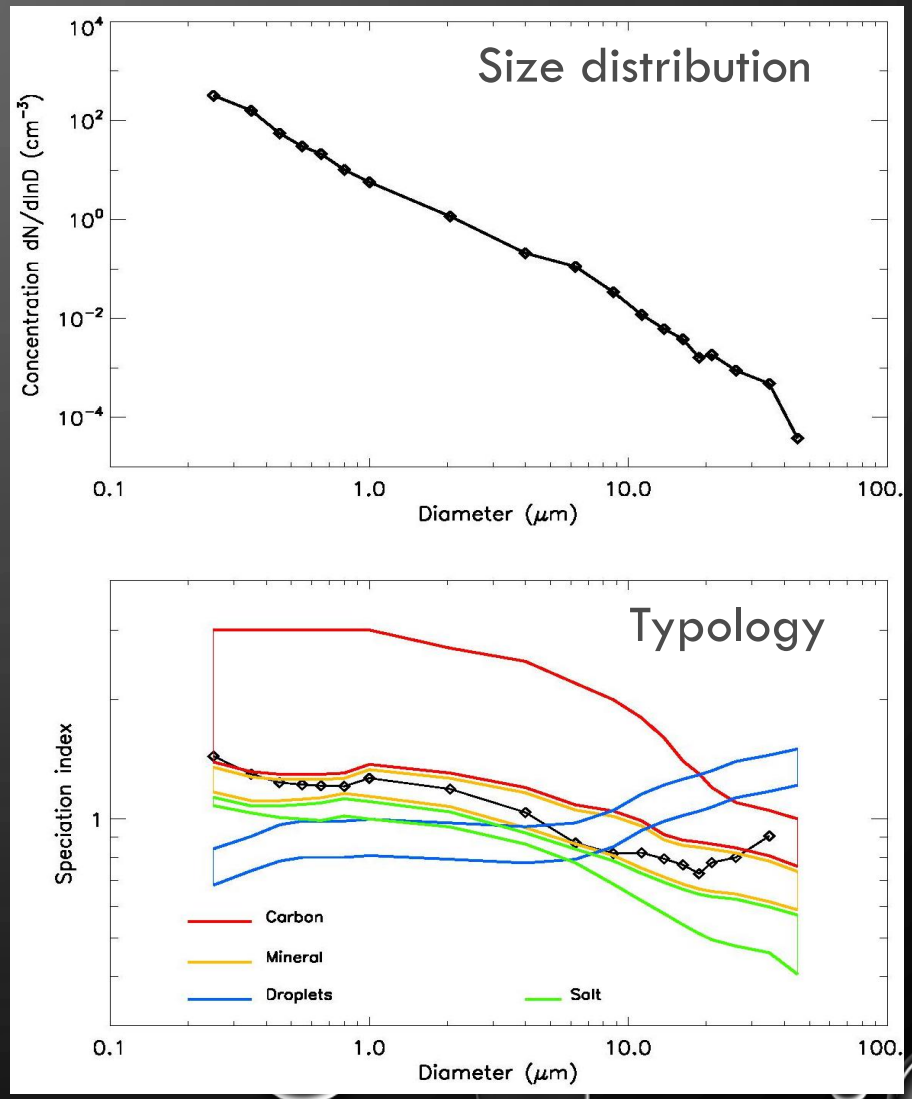


This is an open data base (no more than 3 or 4 different natures at same time)

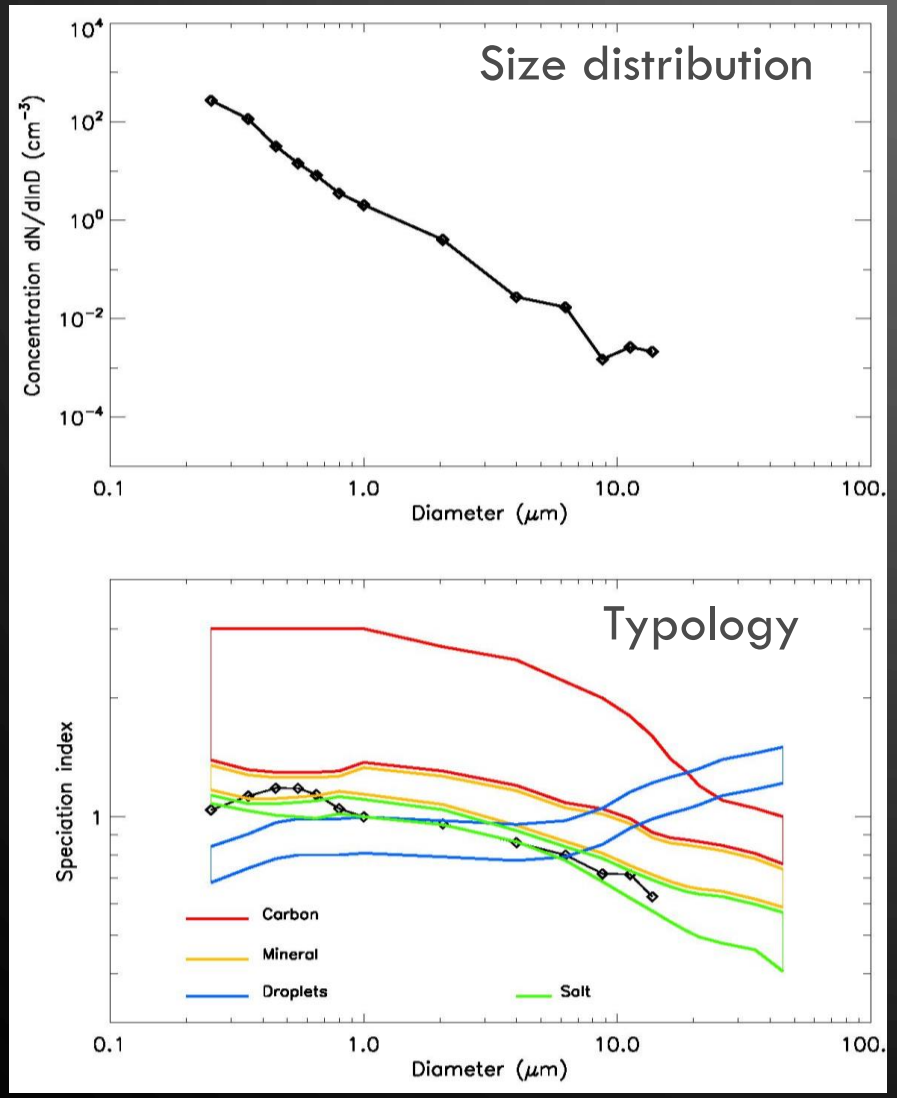
Pollution carbon particles



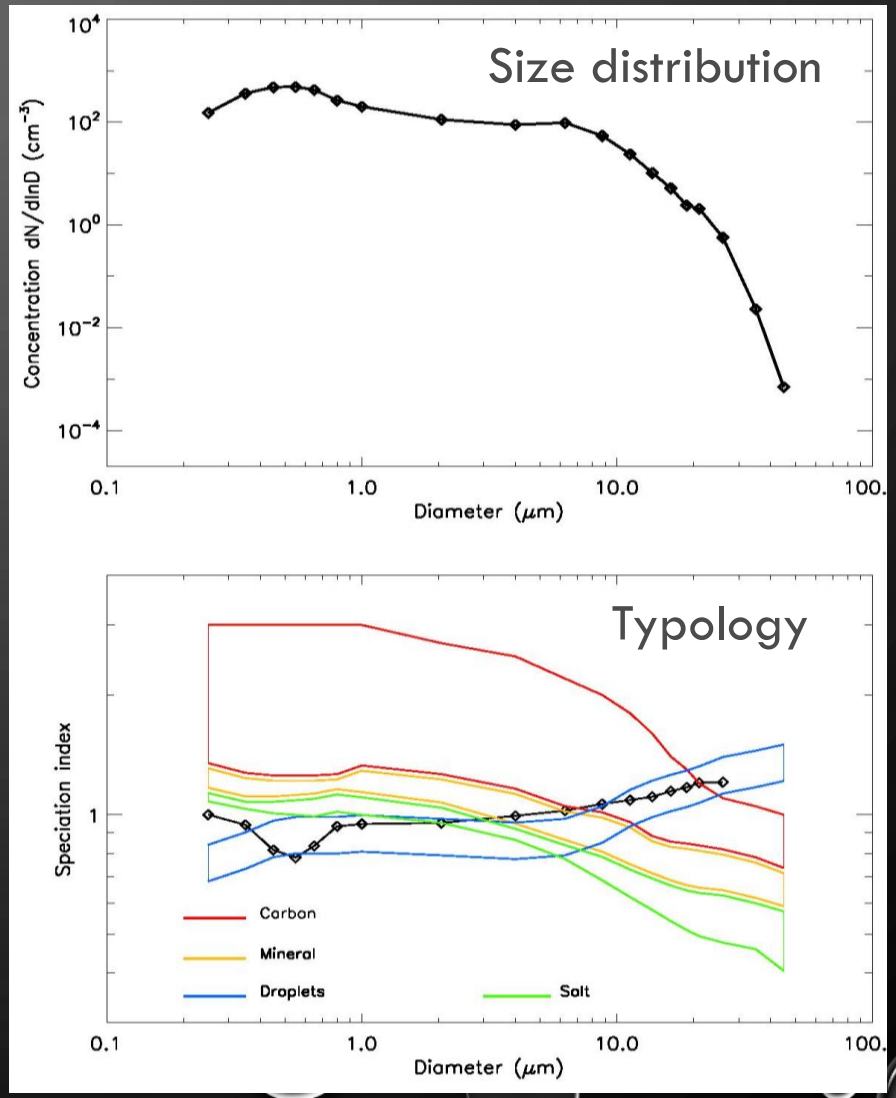
Saharan sand plume



Sea salt

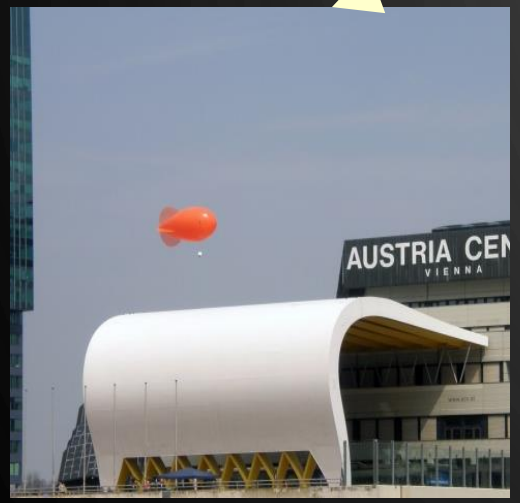


Inside a cloud/fog



LOAC is used at ground and under all kinds of balloons:

tethered, weather, low troposphere, stratosphere





“Modular” instrument : LOAC can work with different kinds of pump (between 1.3 and 2.7 litres/mn) and with different kinds of inlets depending on the sampling conditions

Network of permanent measurements (France)

Touristic balloons :

Ballon Generali, Paris : 0 - 300 m

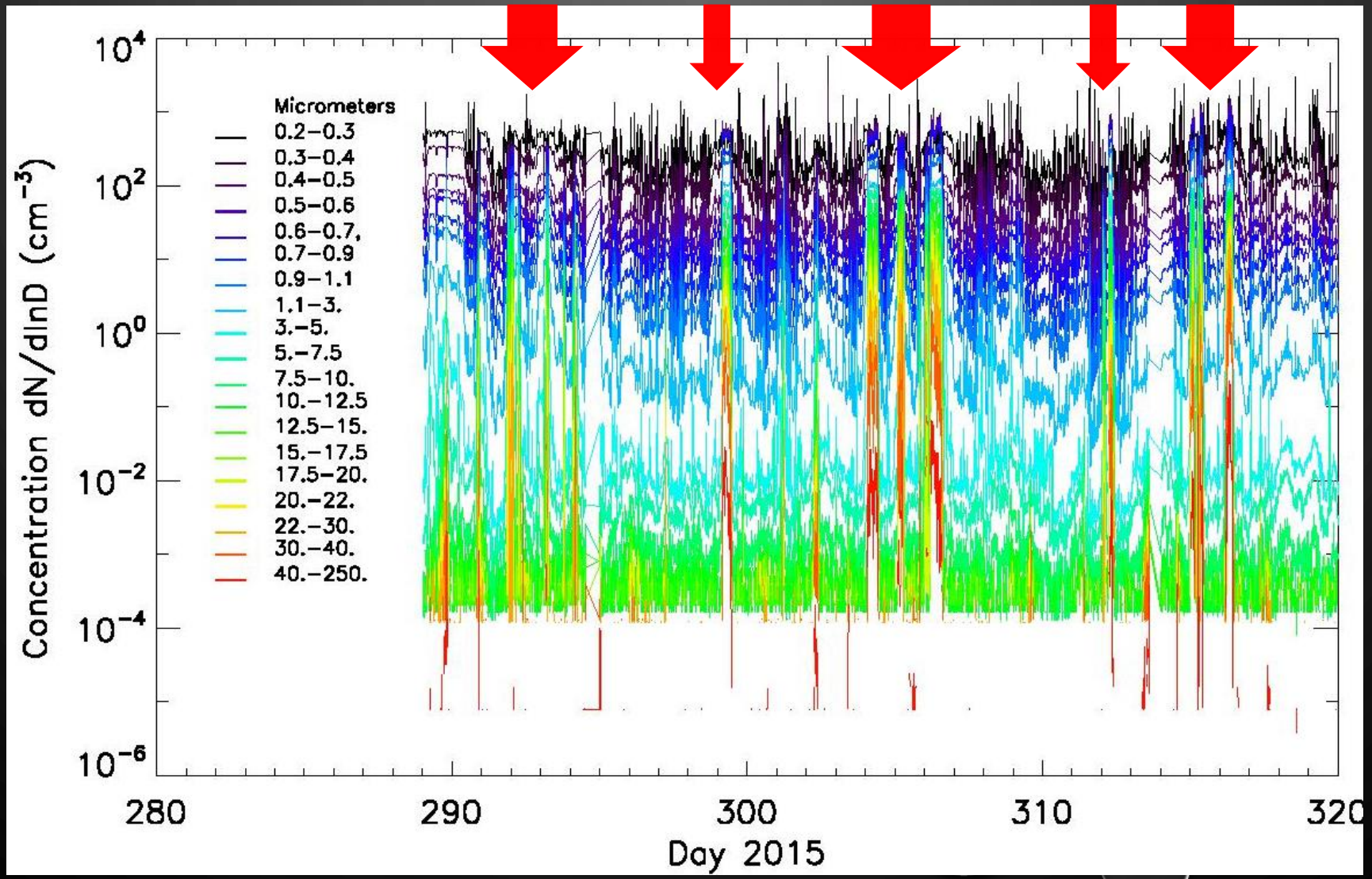
Terra Botanica (Angers) : 0 - 150 m

Ground stations :

SIRTA observatory, Palaiseau

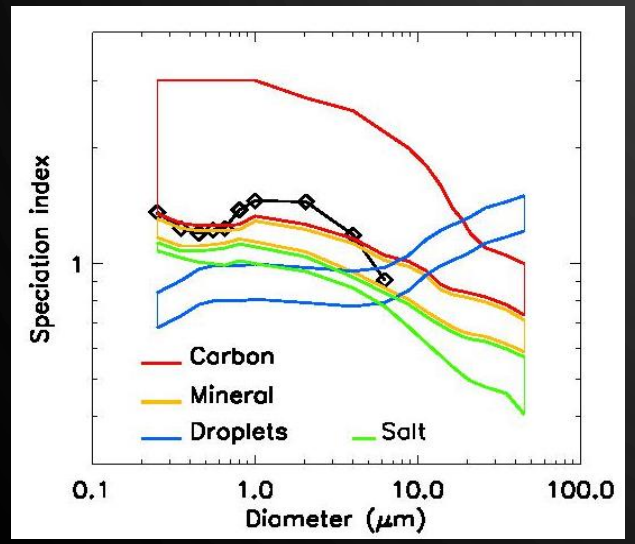
Voltaire site, CNRS, Orléans

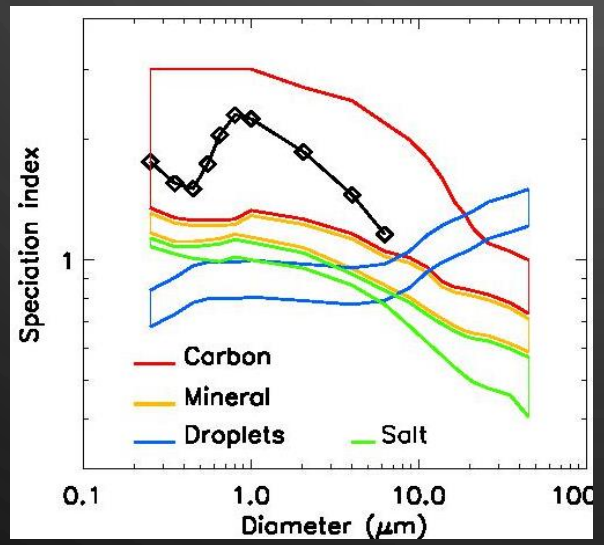
Measurements at ground (SIRTA, Palaiseau) during fog events



Measurements on board the touristic balloon "AOG" in Paris

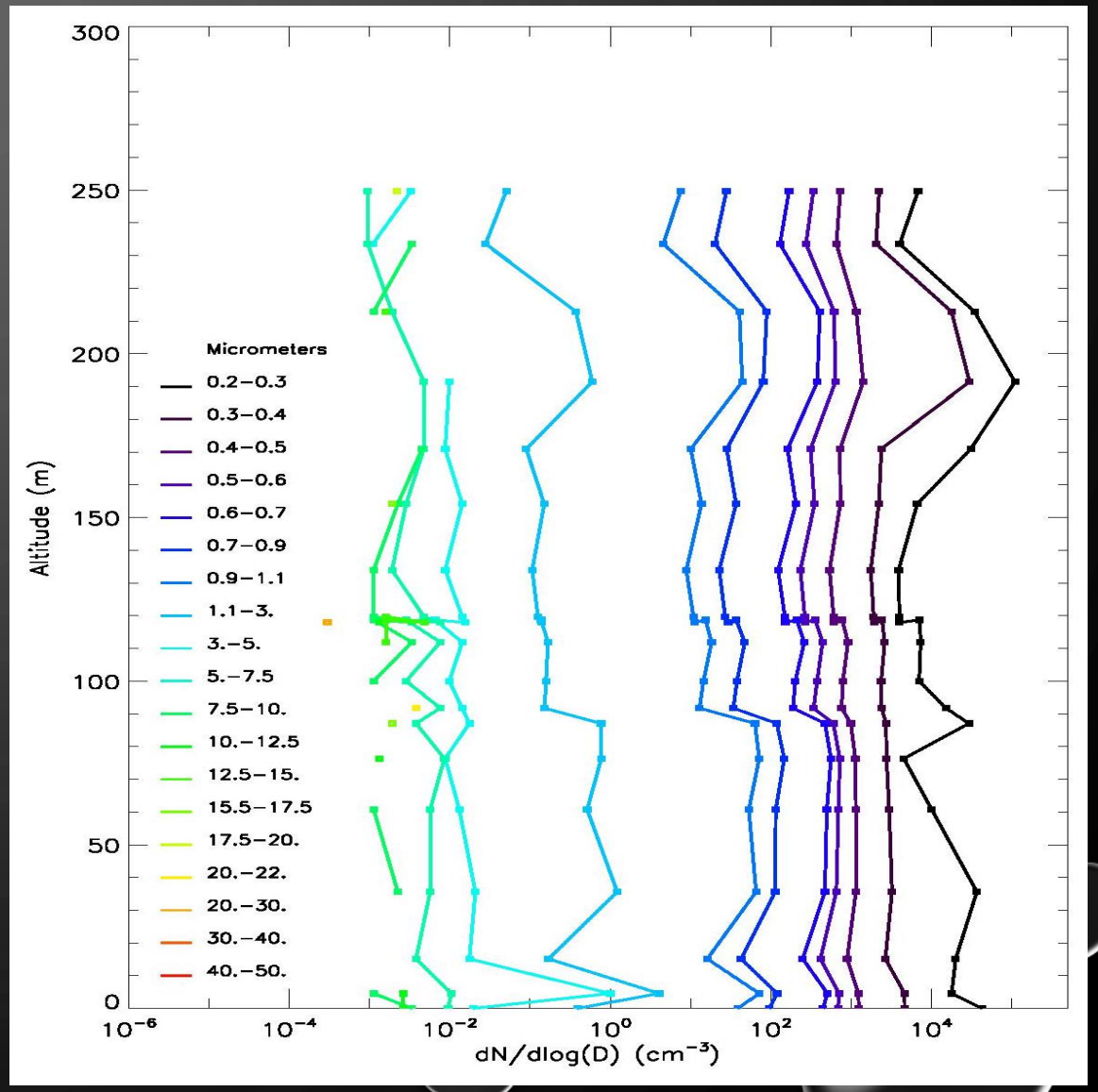
Strong pollution event on 11 December 2013 and inversion layer at an altitude of 200 m





Close to the ground, various natures

At 200m, black carbon



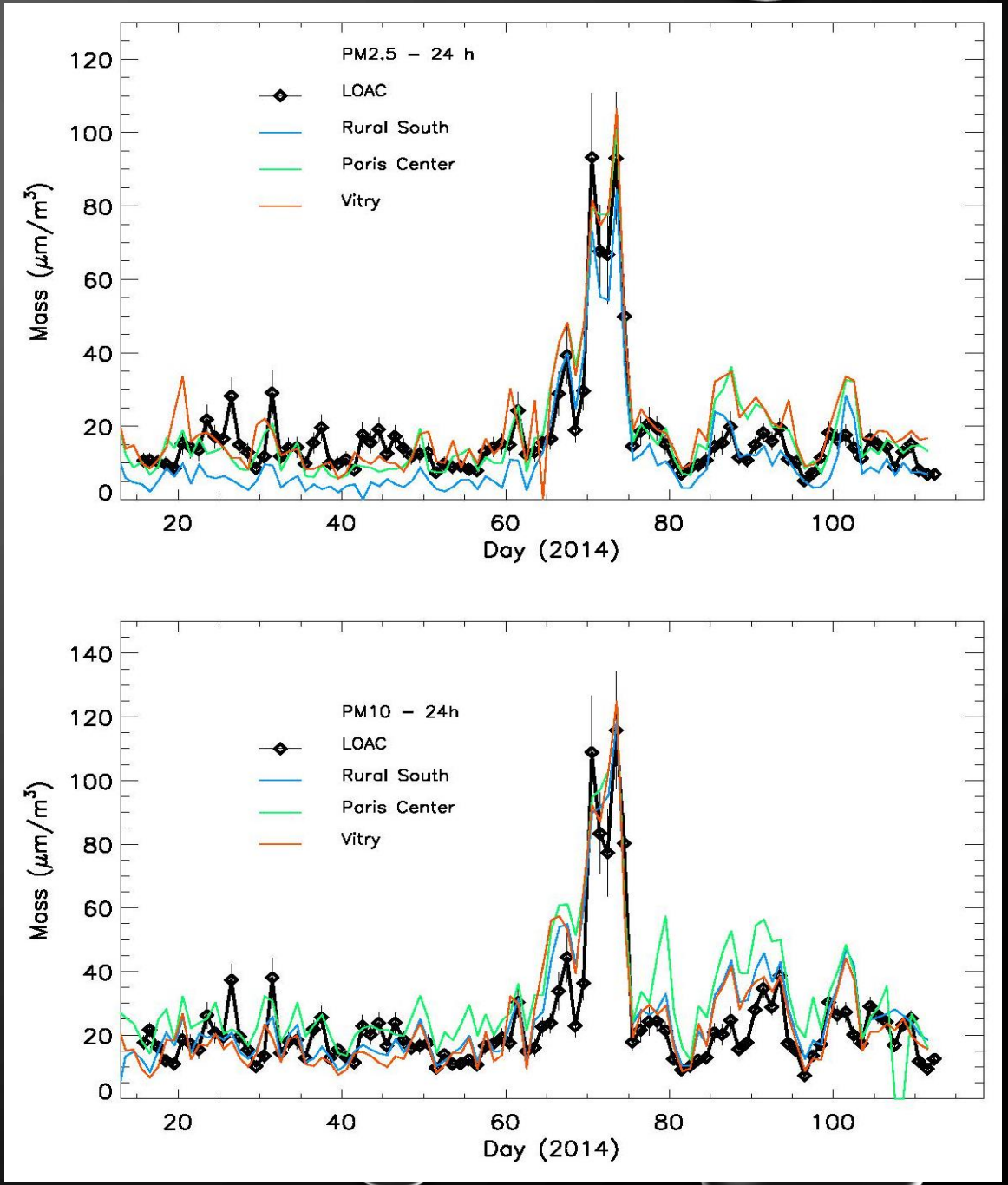
Counting measurements can be converted to PM 2.5 and PM10 mass (µg/m^3)

Mean densities used from speciation results:

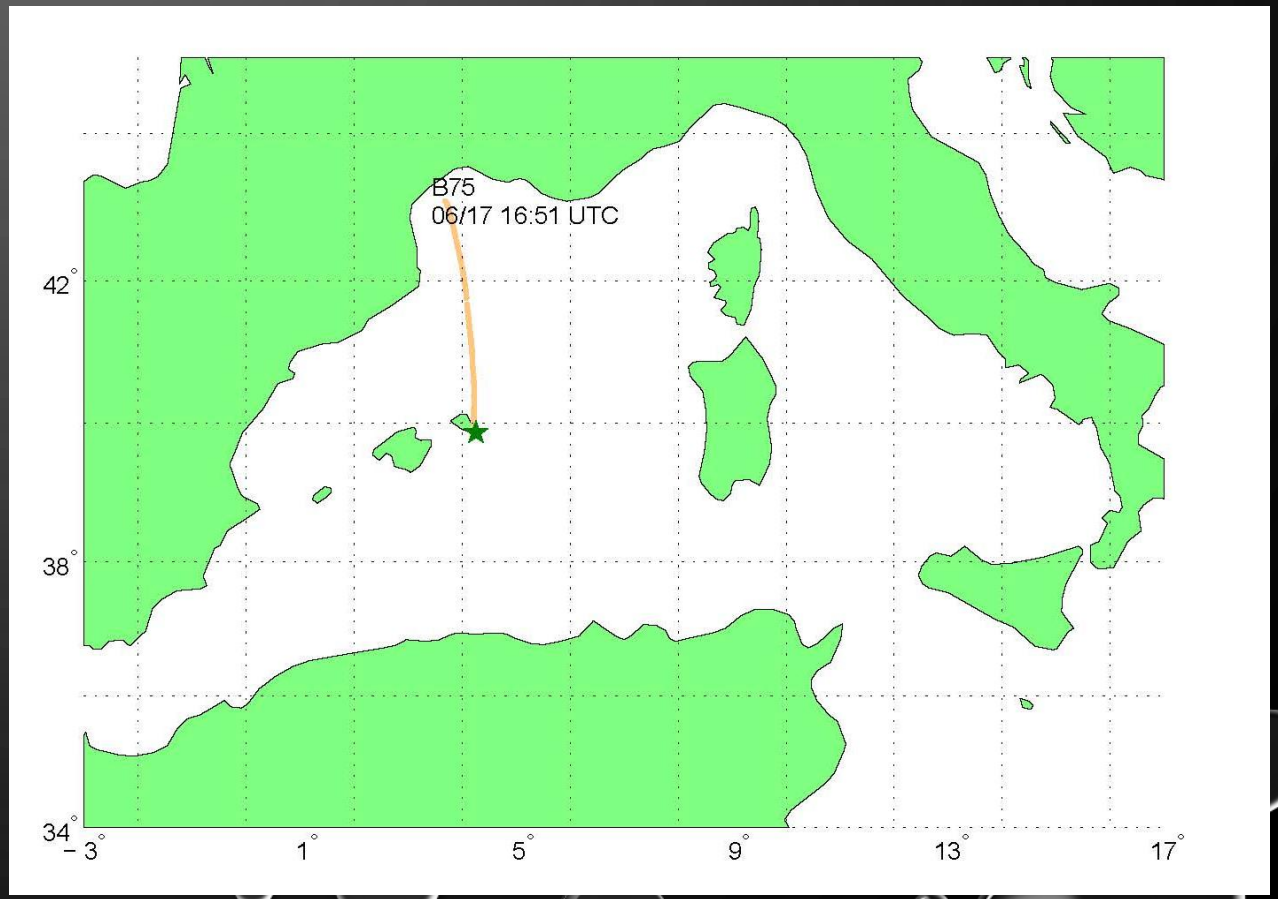
1.6 g/cm^3 for carbon

2.2 g/cm^3 for minerals and salts

Comparison with reference microbalance measurements from Airparif ambient air network



LOAC has performed 19 flight under drifting tropospheric balloons and 12 flights under weather balloon during the ChArMex campaign, Summer 2013, above the Mediterranean Sea

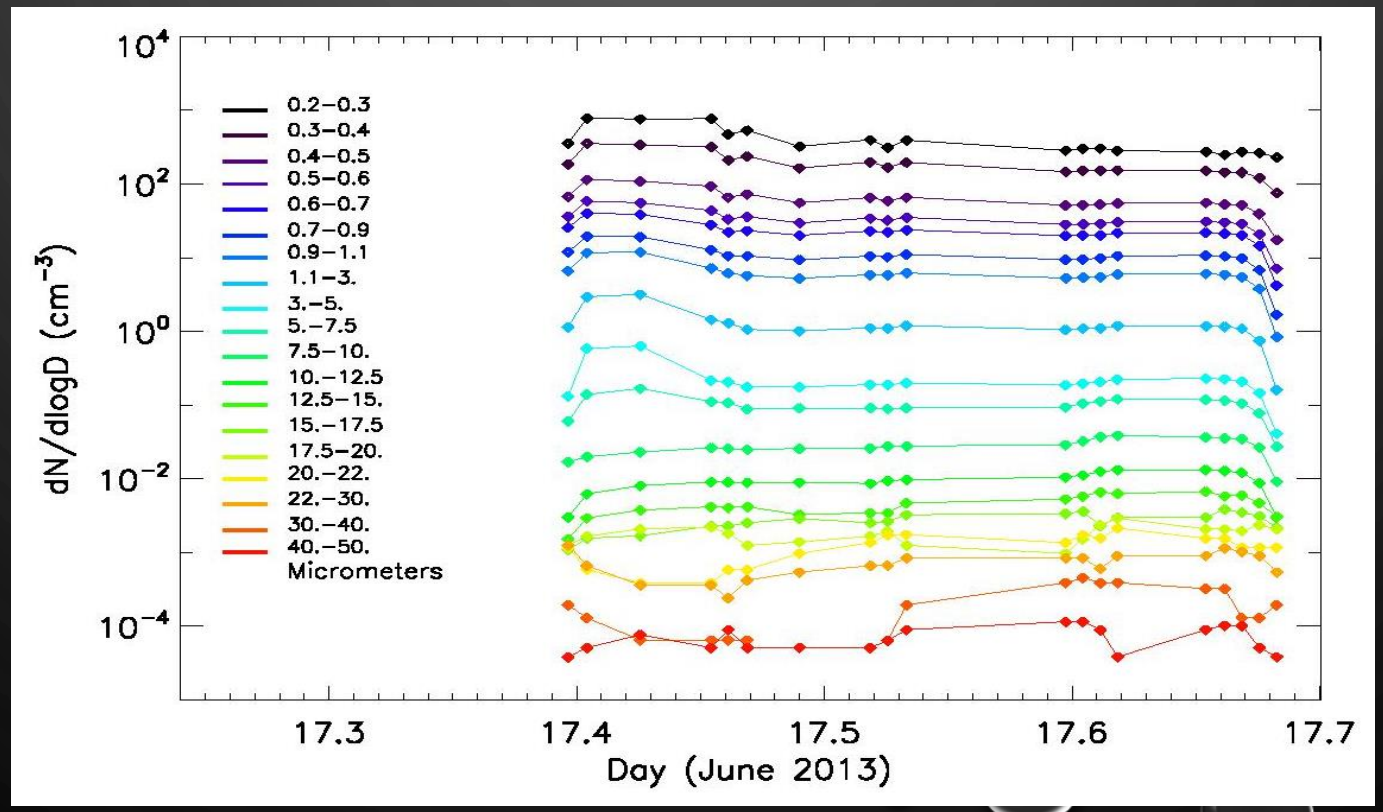


BPCL trajectory on 17 June 2013, altitude of 2000 m

Drifting balloon flight inside a Saharan sand plume

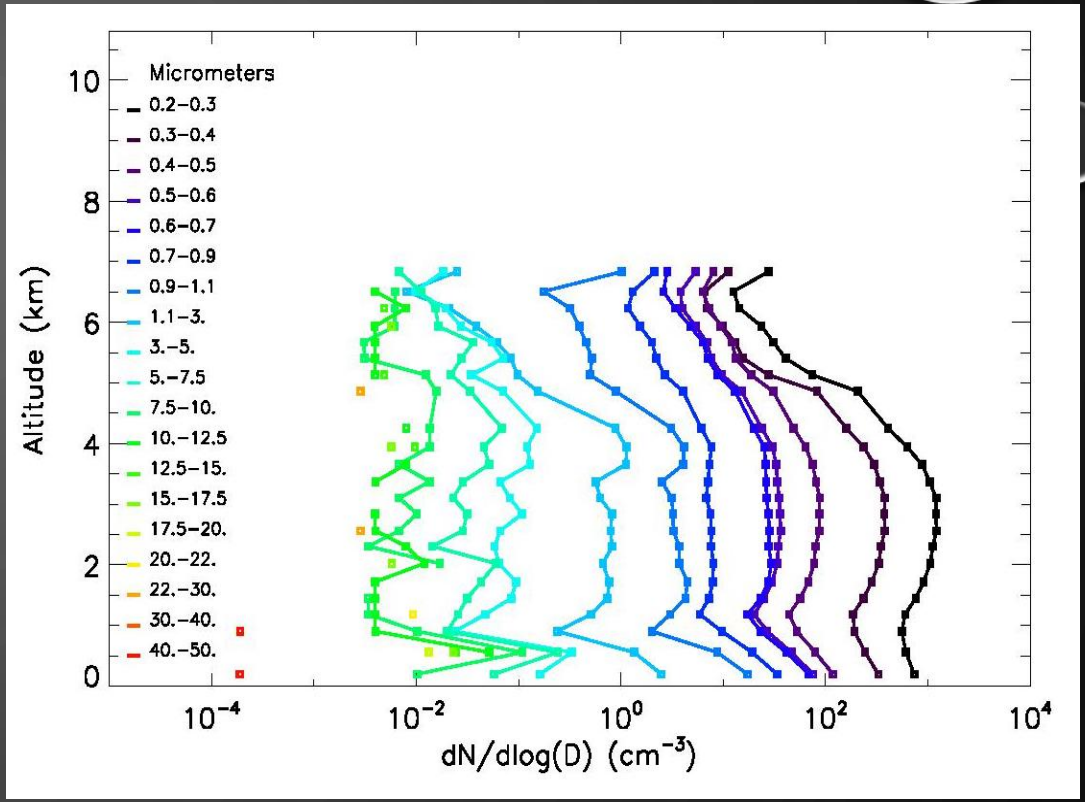
17 June 2013, from Minorca (Spain), altitude of 2 km

Detection of large particles transported during several days

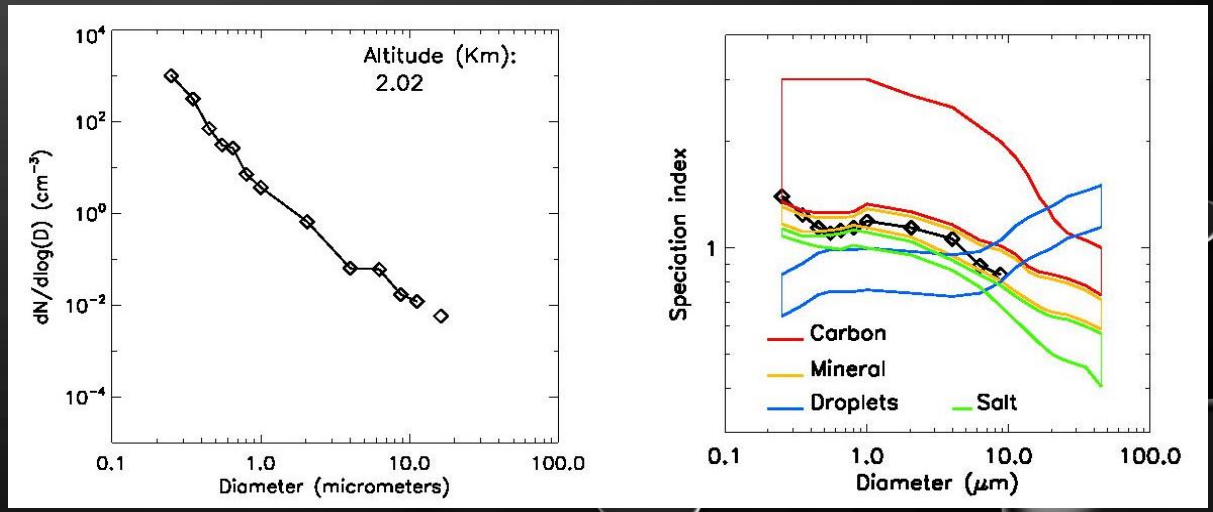


- **Flight under weather balloon inside a Saharan dust plume**

18 June 2013 from Minorca



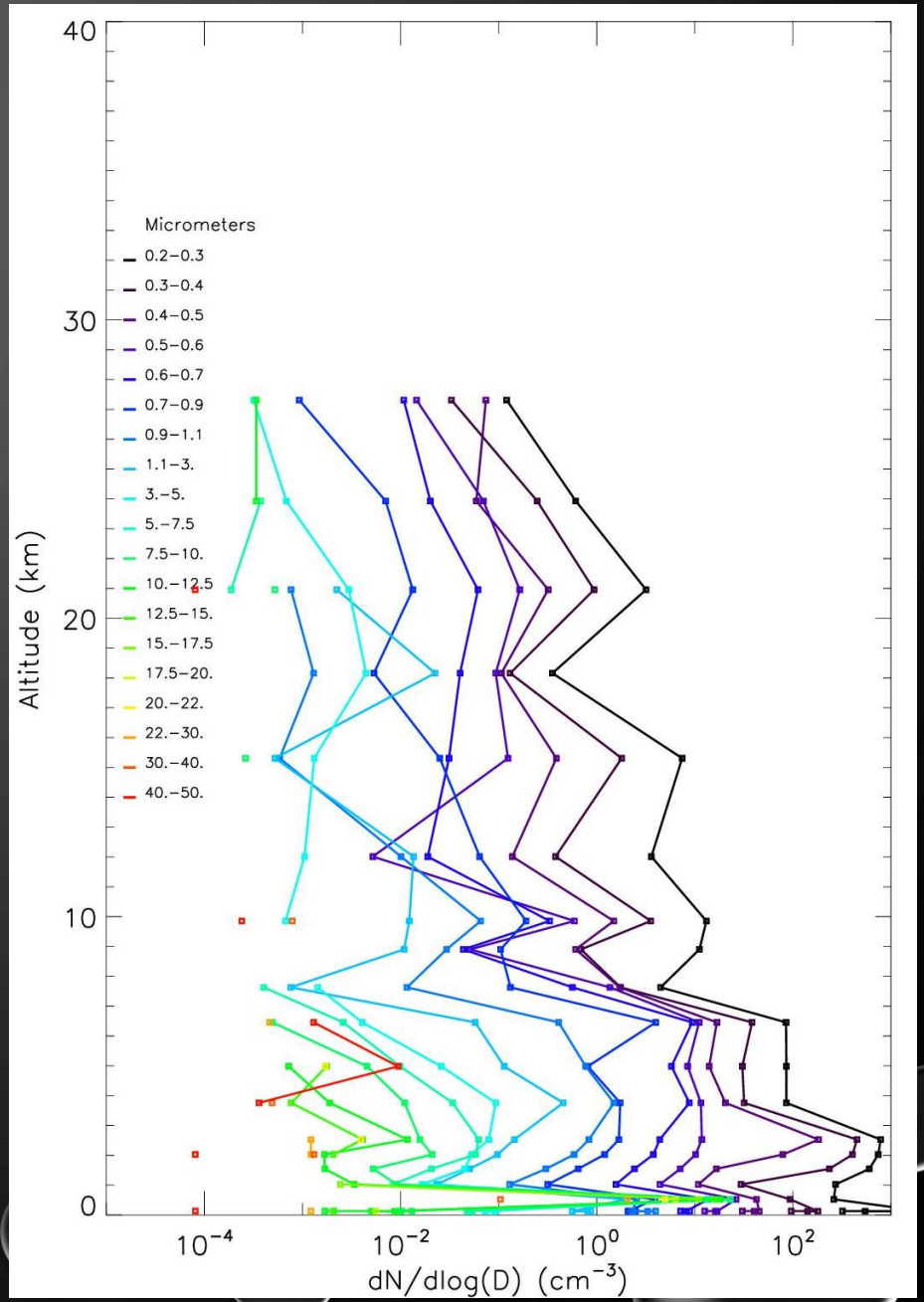
Size distribution and typology



LOAC performs regular flights under weather balloons in the stratosphere, since 2014

LOAC-VOLTAIRE campaign, monitoring of the stratospheric aerosol content

12 August 2015, from Aire sur l'Adour (France)



Fly on-board Unmanned Airborne Vehicle, ADE (Affrètement Drone et Environnement) Company

Environmental studies, analysis of local sources

CONCLUSIONS

LOAC provides the size distribution and the main nature of the aerosols

Light instrument for ground and airborne measurements

Actual scientific campaigns:

Pollution studies with the LOAC network

LOAC- VOLTAIRE, long-term monitoring of the stratosphere (~35 flights per year at different latitudes)

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The LOAC flights are preformed by the French space agency CNES

- Contact for science application: jbrenard@cnrs-orleans.fr

- LOAC is commercialized by the MeteoModem company: http://www.meteomodem.com

- LOAC on board Unmanned Airborne Vehicles is commercialized by the Fly-N-Sense company : http://www.fly-n-sense.com/