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Illustration of balloon-borne dust aerosol measurements with the aerosol counter LOAC during ChArMEx

development funded by:

F. Dulac[1], J.-B. Renard[2], M. Jeannot[2], D. Vignelles[2], G. Berthet[2], F. Jégou[2], N. Verdier[3], P. Durand[4], B. Barret[4], C. Jambert[4], M. Mallet[4] C. Basdevant[5], J.-C. Dupont[5] A. Doerenbecher[6], J. Totems[1], P. Chazette[1] C. Thaury[7], T. Tonnelier[7], P. Charpentier[8]

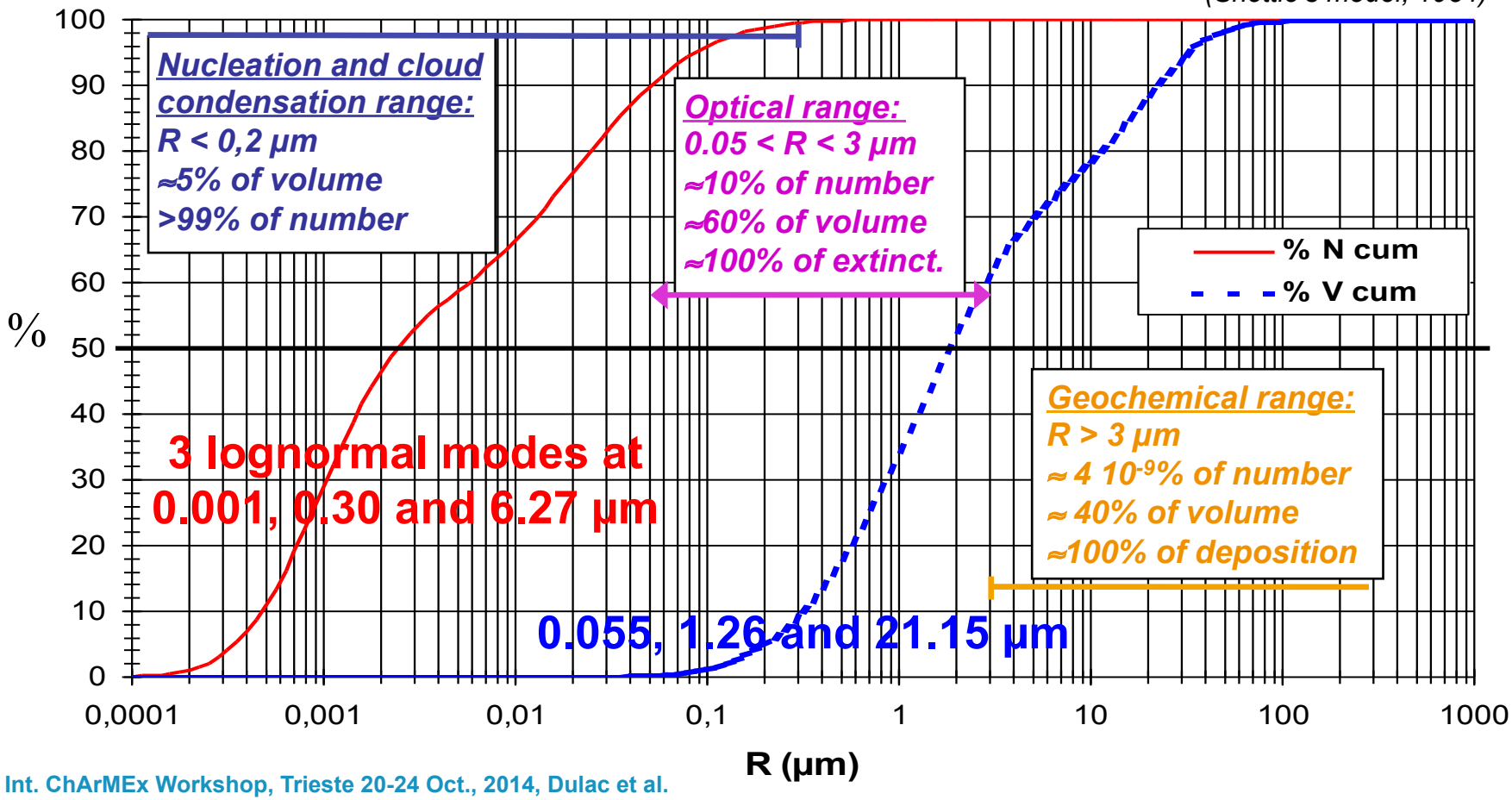
[1] ***LSCE-IPSL***, *CEA-CNRS-UVSQ, Gif-sur-Yvette, France*
[2] ***LPC2E***, *Orléans, France*
[3] ***CNES***, *Toulouse, France*
[4] ***LA***, *Toulouse, France*
[5] ***LMD***, *Palaiseau, France*
[6] ***CNRM***, *Toulouse, France*
[7] ***Environnement S.A.***, *Poissy, France*
[8] ***MeteoModem***, *Toulouse, France*
* ***Contact:*** ***Francois.Dulac@cea.fr***

Why addressing the aerosol size distribution ?

⇨ **Particle number, surface or volume/mass control different processes**

Relative cumulated distributions in number and volume of the backgound desert aerosol

(Shettle's model, 1984)



Need for a balloonborne OPC

Objectives

- ⇨ Observe Lagrangian aerosol evolution, especially in desert dust plumes
- ⇨ Measure the aerosol particle size distribution in the vertical
- ⇨ Cover the maximum size range possible (submicron range for pollution and ≥20 µm for desert dust)

Strategy

- ⇨ Use of balloons for in situ measurements, combining
  - CNES drifting boundary-layer pressurized balloons (BLPB) are designed to last several weeks for unique quasi-Lagrangian monitoring
  - Soundings BLPB flights for vertical distribution

Challenge

- ⇨ Develop a small balloonborne optical particle counter/sizer with a larger size range than existing devices
- ⇨ Possibly distinguish between different types of particles

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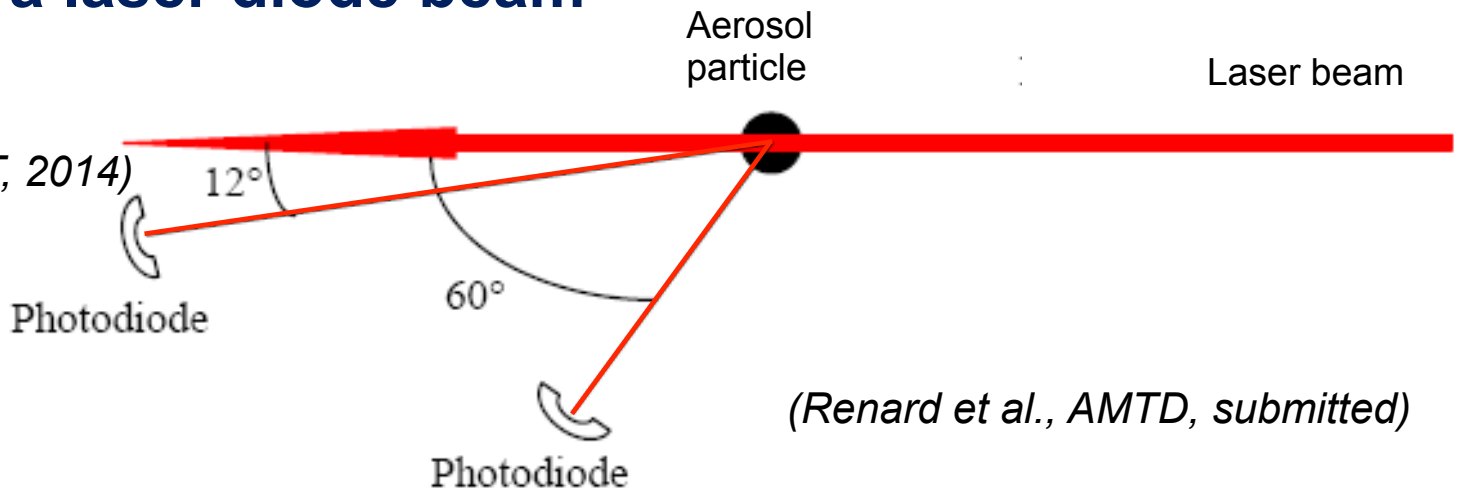
LOAC principle

Light Optical Aerosol particle Counter/sizer: measurements of the light scattered by the aerosols crossing a laser diode beam



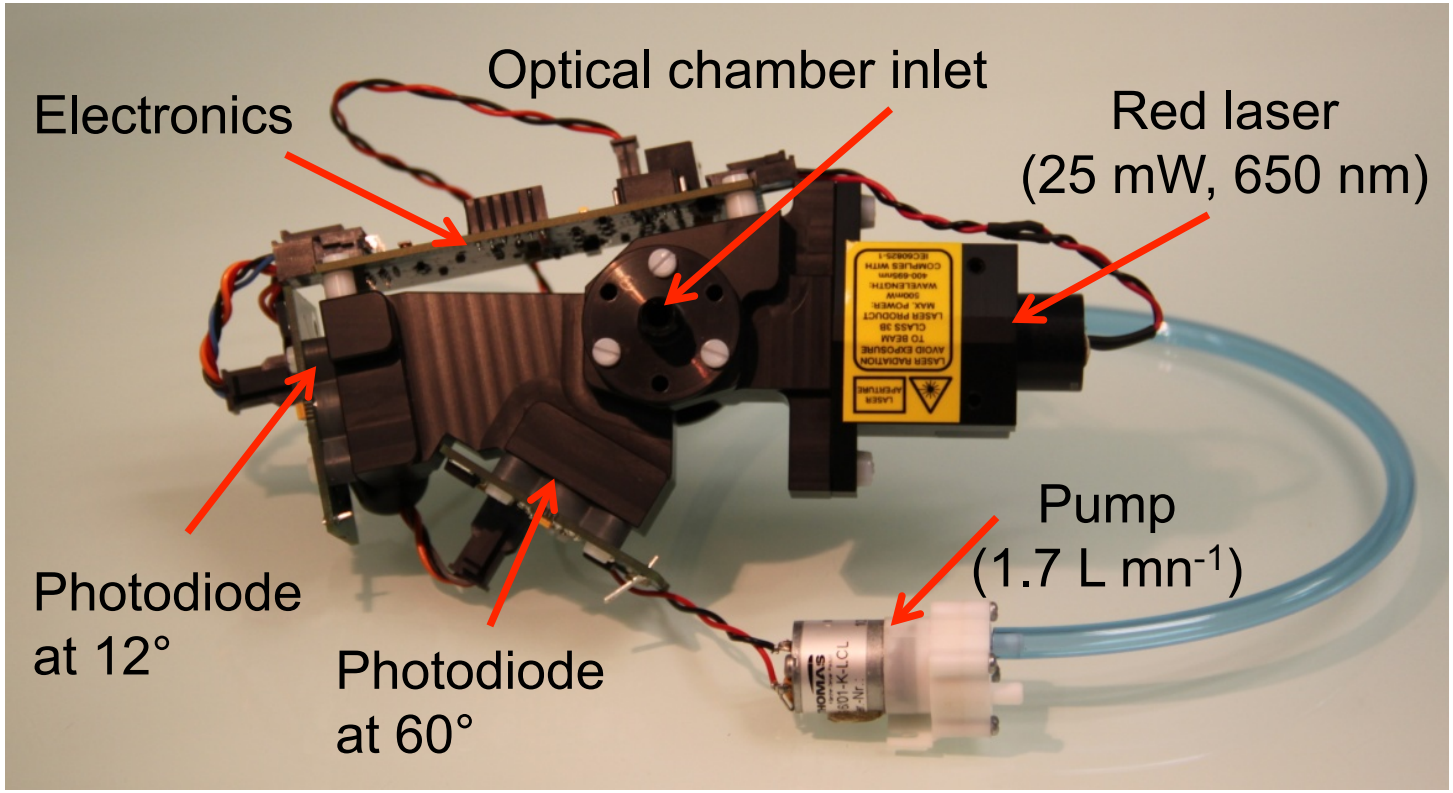
(Lurton et al., AMT, 2014)

(Renard et al., AMTD, submitted)

⇨ **OPC with measurements at 2 scattering angles**

- **near forward direction: scattered light is relatively insensitive to the aerosol nature => accurate size determination**
  - **high flux near forward direction => more sensitivity**
- **side direction: scattered light very sensitive to particle nature**

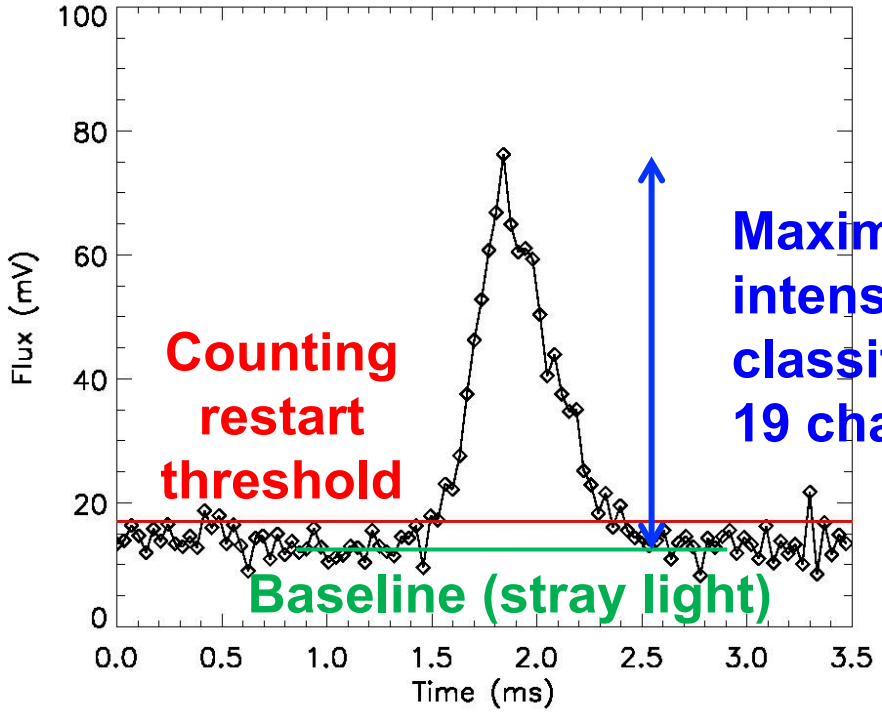
LOAC instrument



⇨ **250 g incl. pump, 3 W consumption under 8 V**

LOAC channels

Signal from a 5 µm particle

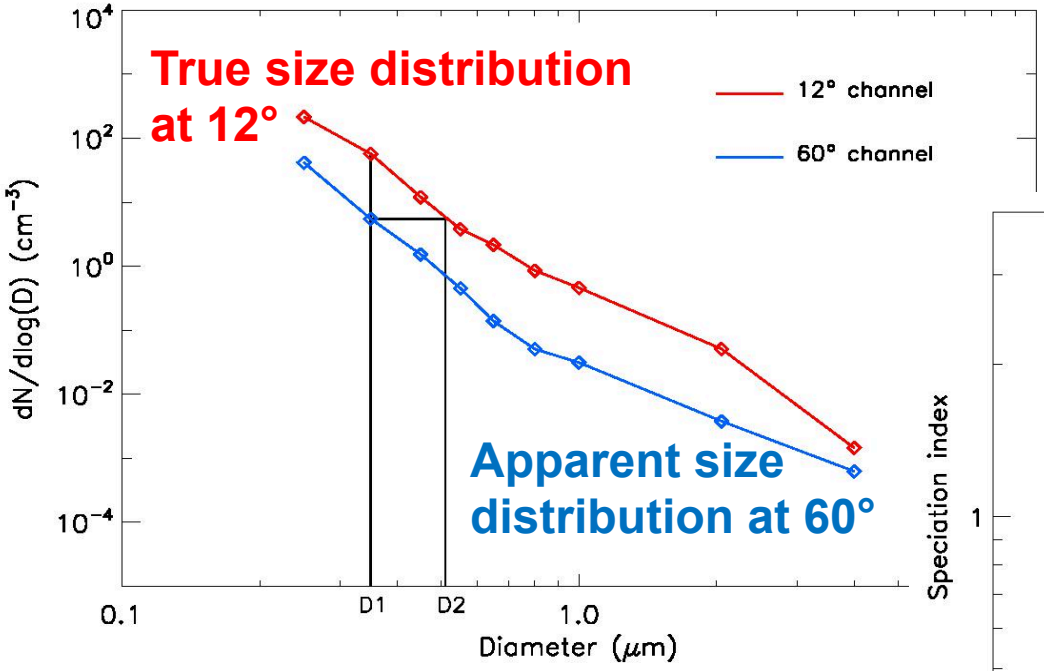


⇨ **Calibration is performed with particles of known size using the 12° channel**

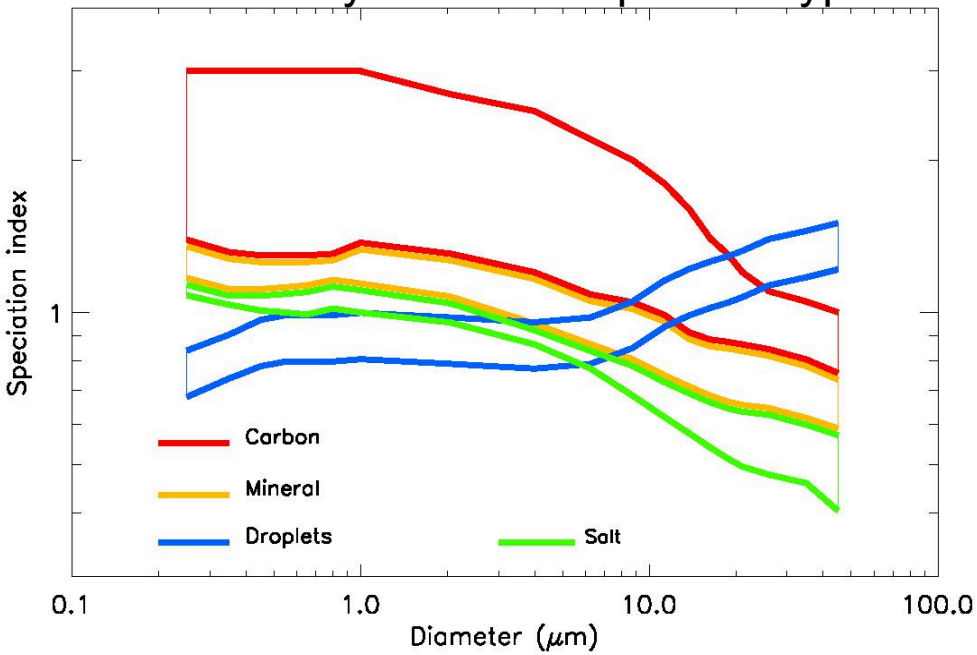
Diameter classes (µm)

0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.9
0.9 - 1.1
1.1 - 3.0
3.0 - 5.0
5.0 – 7.5
7.5 – 10.0
10.0 – 12.5
12.5 – 15.0
15.0 – 17.5
17.5 – 20.0
20.0 - 22.0
20.0 - 30.0
30.-0 - 40.0
40.0 – up to 250.0

LOAC speciation



Speciation index obtained in laboratory for various particle types



⇨ **The same thresholds in mV are applied to both channels, producing a bias in the apparent concentration for a given size class at 60°**

- **The ratio D2/D1 can be used as a speciation index**

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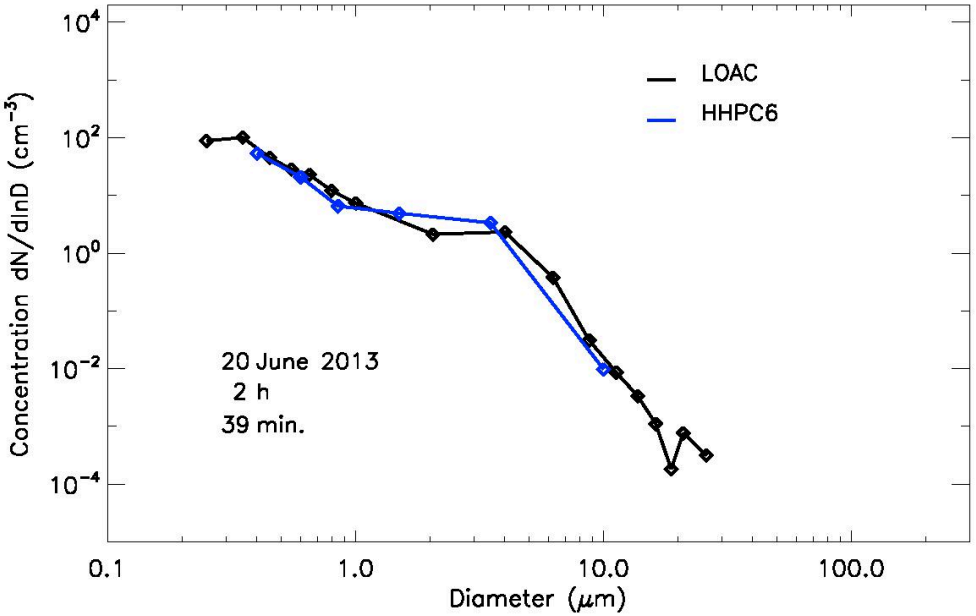
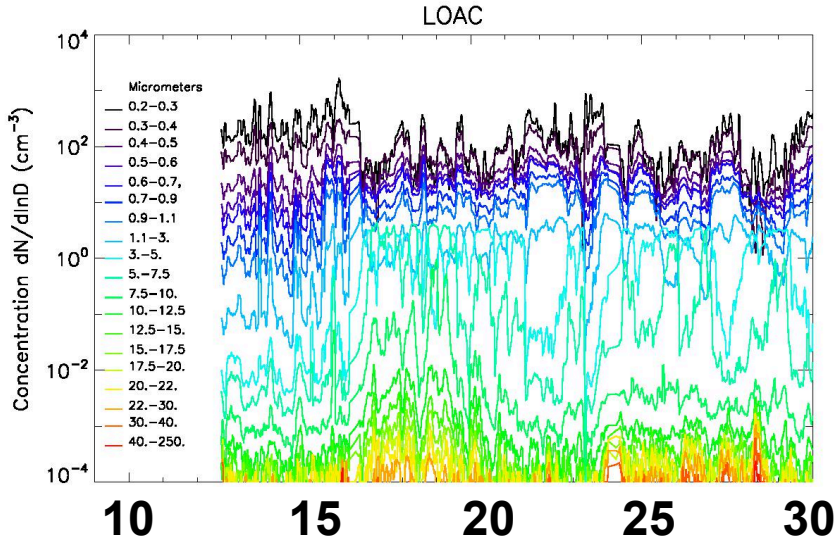
Cross-comparisons: example at Menorca (ChArMEx)

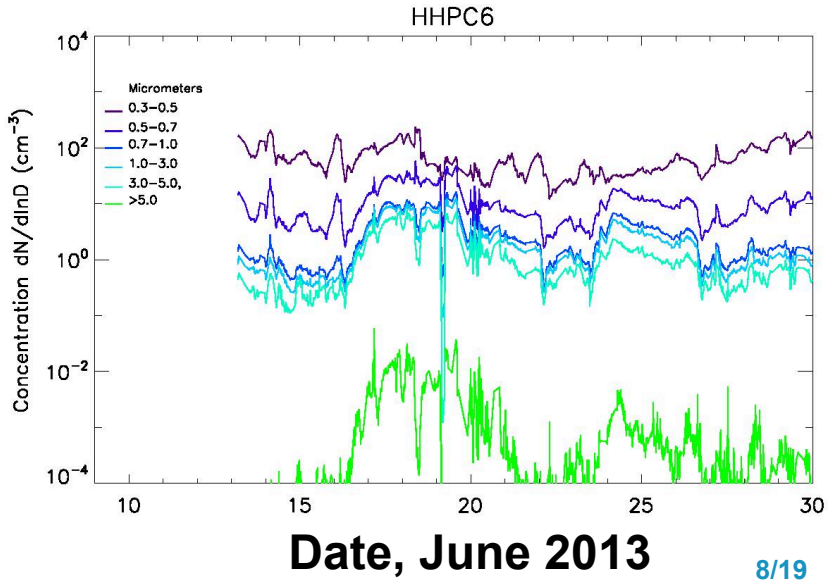
⇨ **...providing confidence in LOAC measurements**

Background conditions



Saharan dust events





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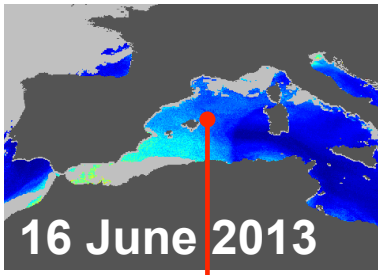
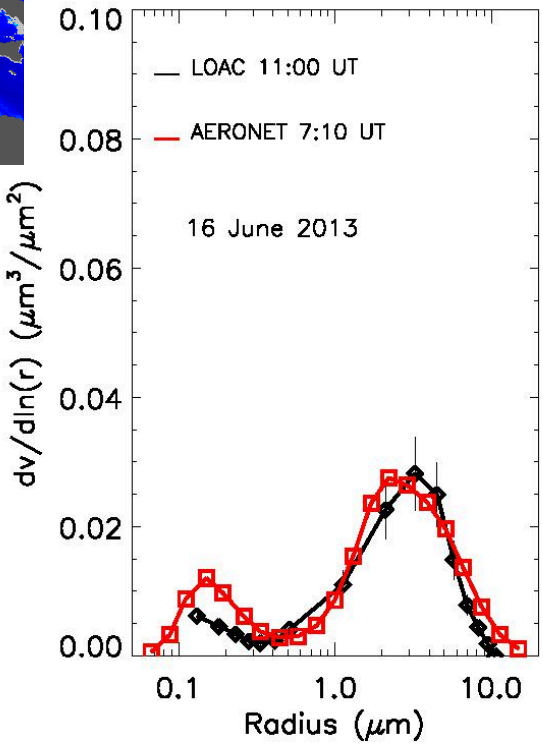
Comparison of the column-integrated size distribution

⇨ **LOAC-derived distribution vertically integrated from sounding measurements at Menorca**



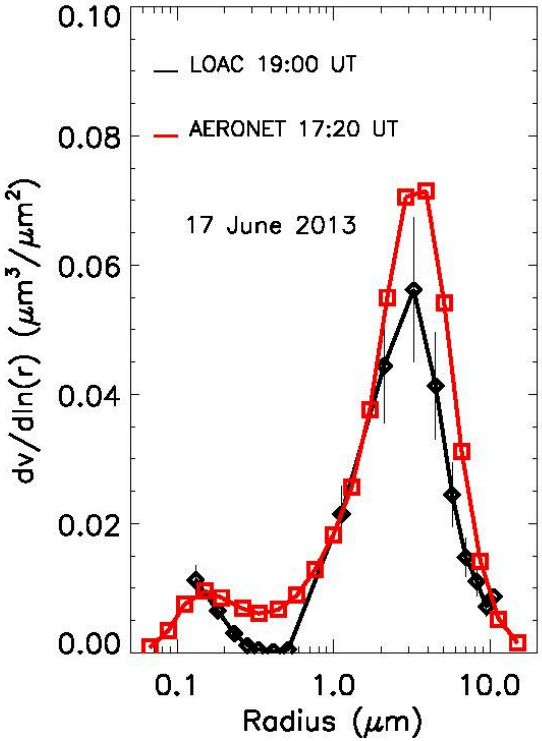
Arrival of Saharan dust

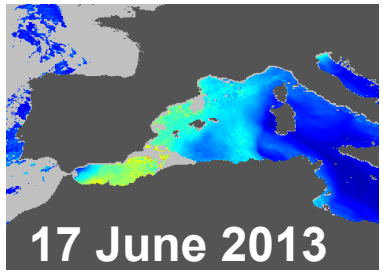
Dust layer: 2-4 km



Moderate dust event

Dust layer: 0.3-5 km



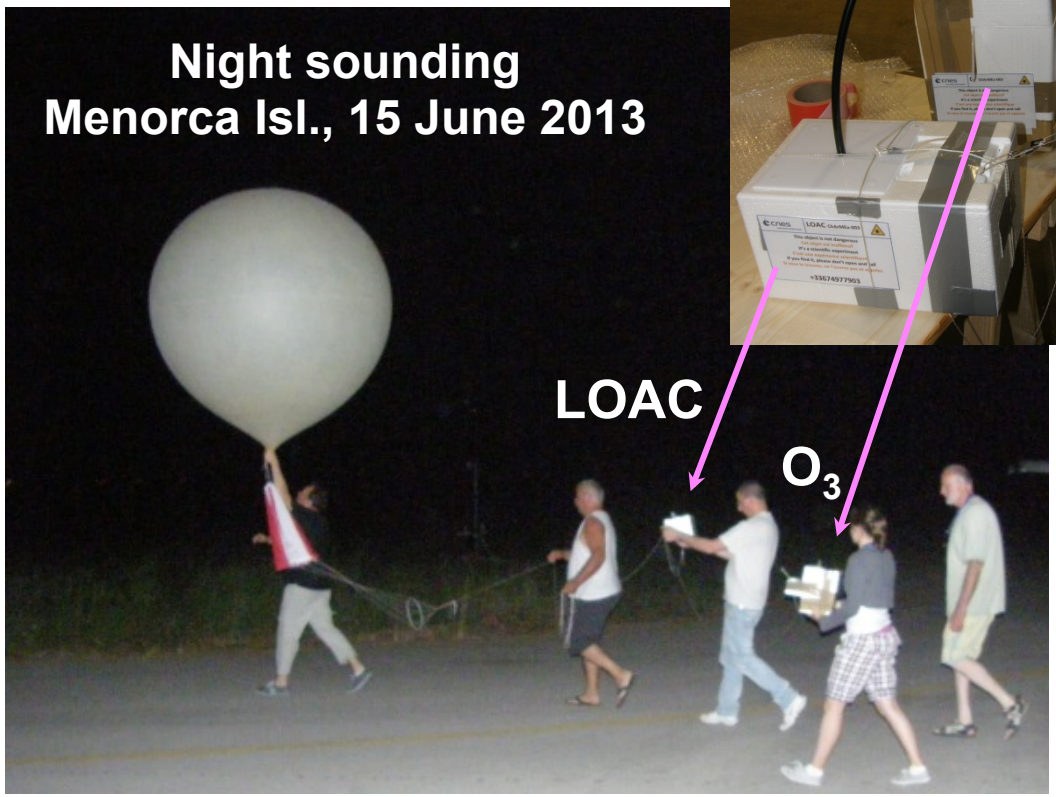


(Renard et al., AMTD, submitted, 2014b)

Sounding balloons

⇨ **LOAC is coupled to a MeteoModem meteorological sonde**

- **total weight of 1 kg with batteries**
- **it can be launched together with an O_3 sonde if 2 reception stations are available**



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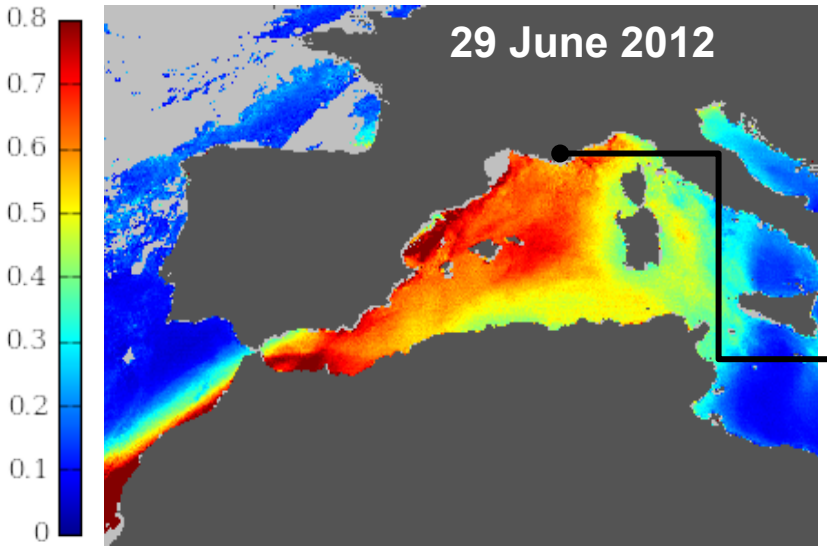
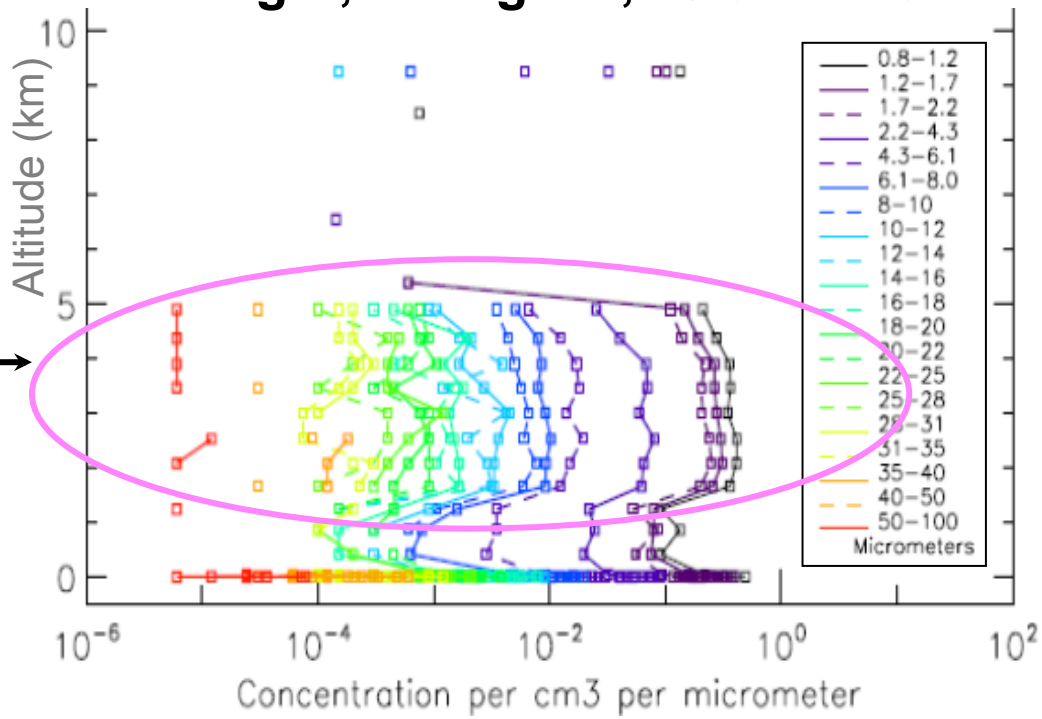
Test flight in 2012 during Pre-ChArMEx/TRAQA

- **Large mineral particles (>25 µm in diameter) within the dust layer between 1 and 5 km**
  - **very clear air above**



Test flight, Martigues, 29 June 2012



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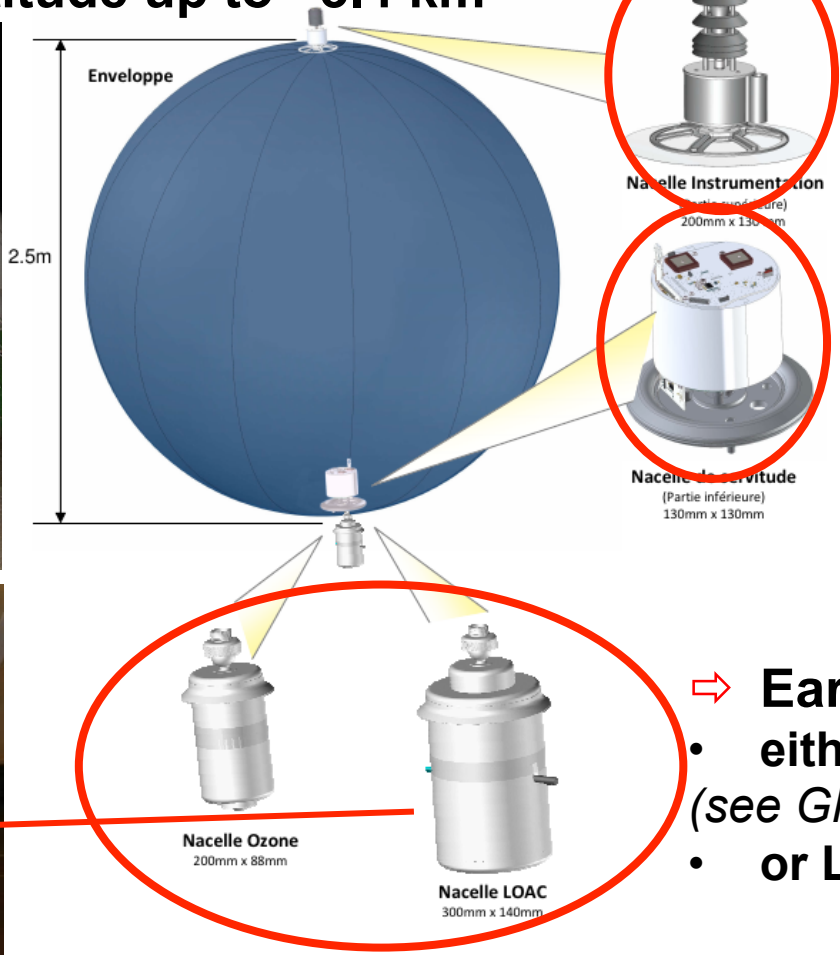
CNES boundary-layer pressurized balloon (BLPB)

⇨ **Larger balloons (2.6-m diam.) launched unpressurized to reach altitude up to ~3.4 km**

(see Dubourg et al.'s presentation)



⇨ **Sky-pole scientific gondola:**
- **P,T,U, solar radiation**

⇨ **Service gondola:**
- **GPS navigation**
- **Data transmission (Iridium satellite phone system)**

⇨ **Earth-pole scientific gondola:**
- **either ozonesonde**

(see Gheusi et al.'s presentation)
- **or LOAC optical particle counter**

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ChArMEx campaigns in the western Mediterranean (summer 2013)

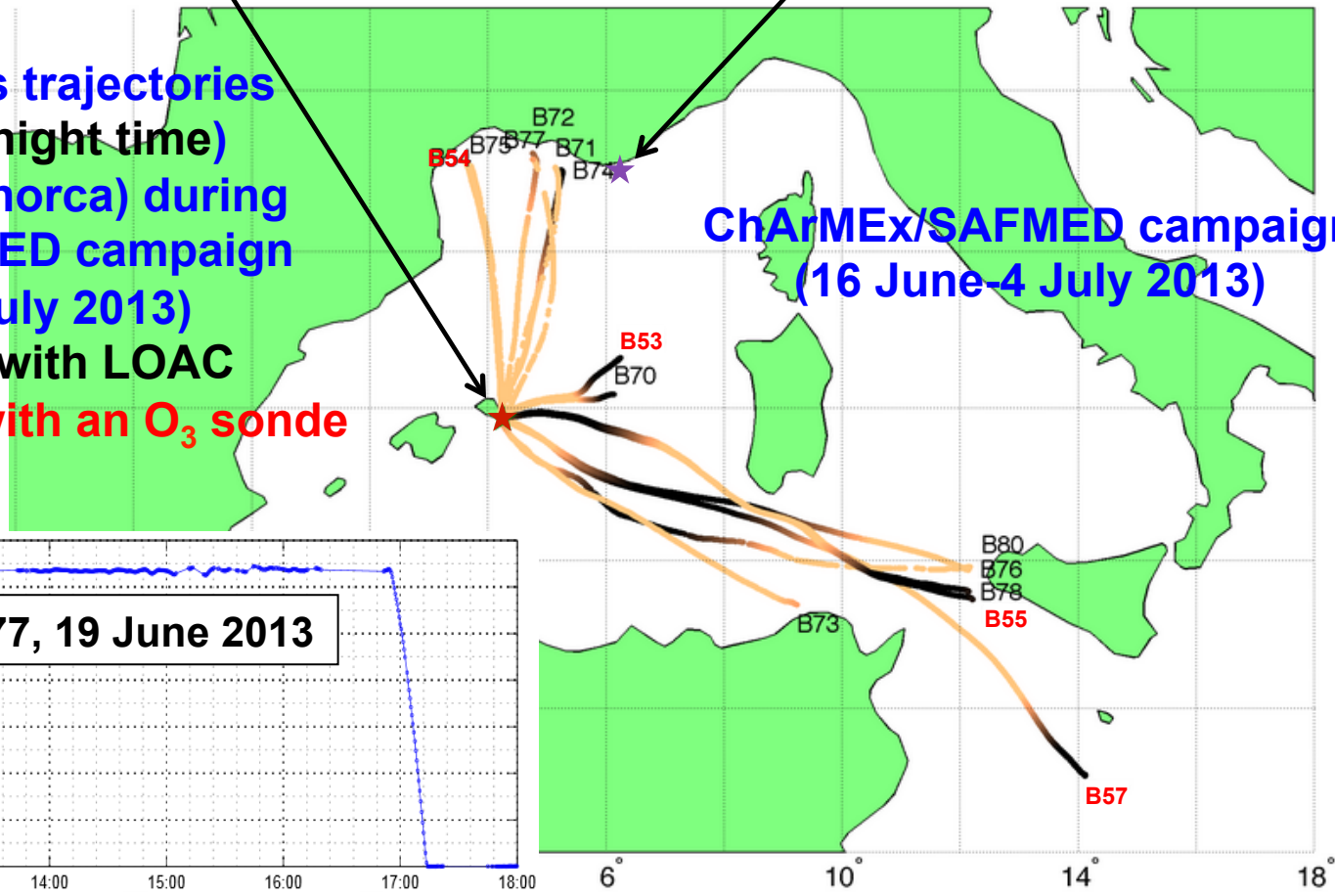
33 launches of LOAC: - 20 with meteo balloons (up to ~36 km)
- 13 with drifting balloons (up to ~26 h)

from both Menorca Isl. for dust and Levant Isl. for pollution

Drifting balloons trajectories (daytime and night time) from Mahon (Menorca) during ChArMEx/ADRIMED campaign (16 June-4 July 2013)

-10 drifting balloons with LOAC

-4 drifting balloons with an O_3 sonde



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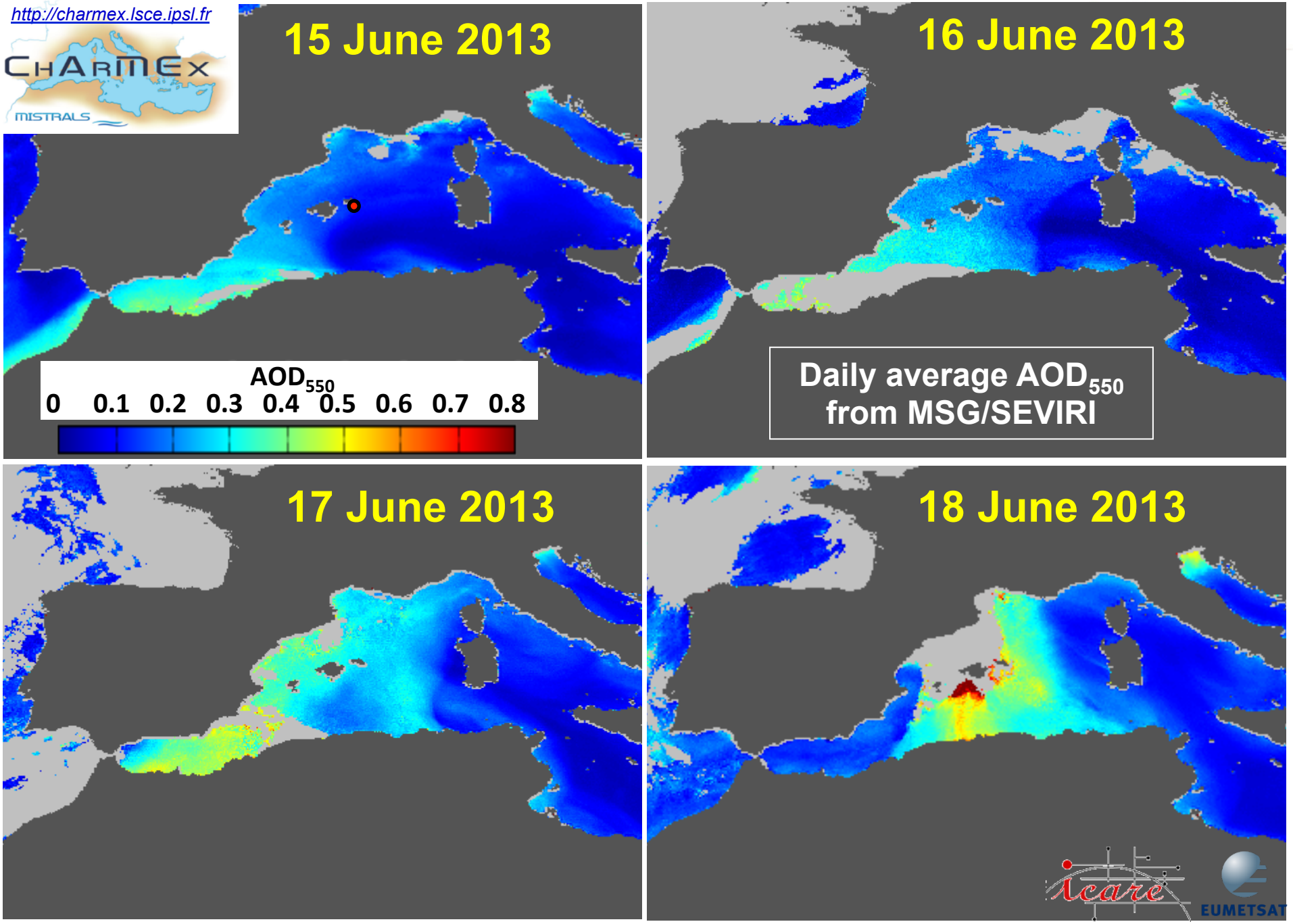

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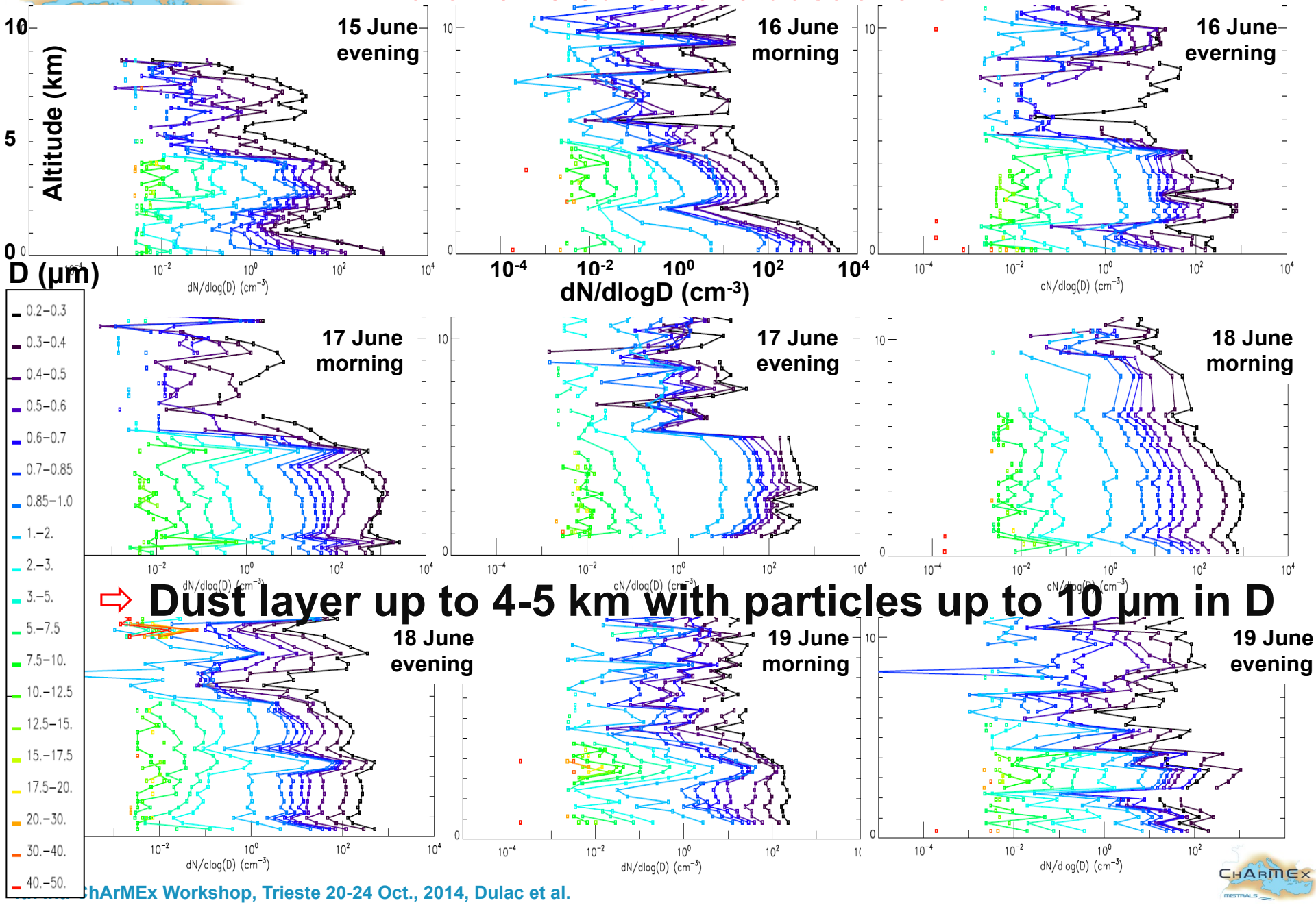
Sounding every ~12 hours during the 15-19 June 2013 dust event



⇨ **Dust layer up to 4-5 km with particles up to 10 µm in D**

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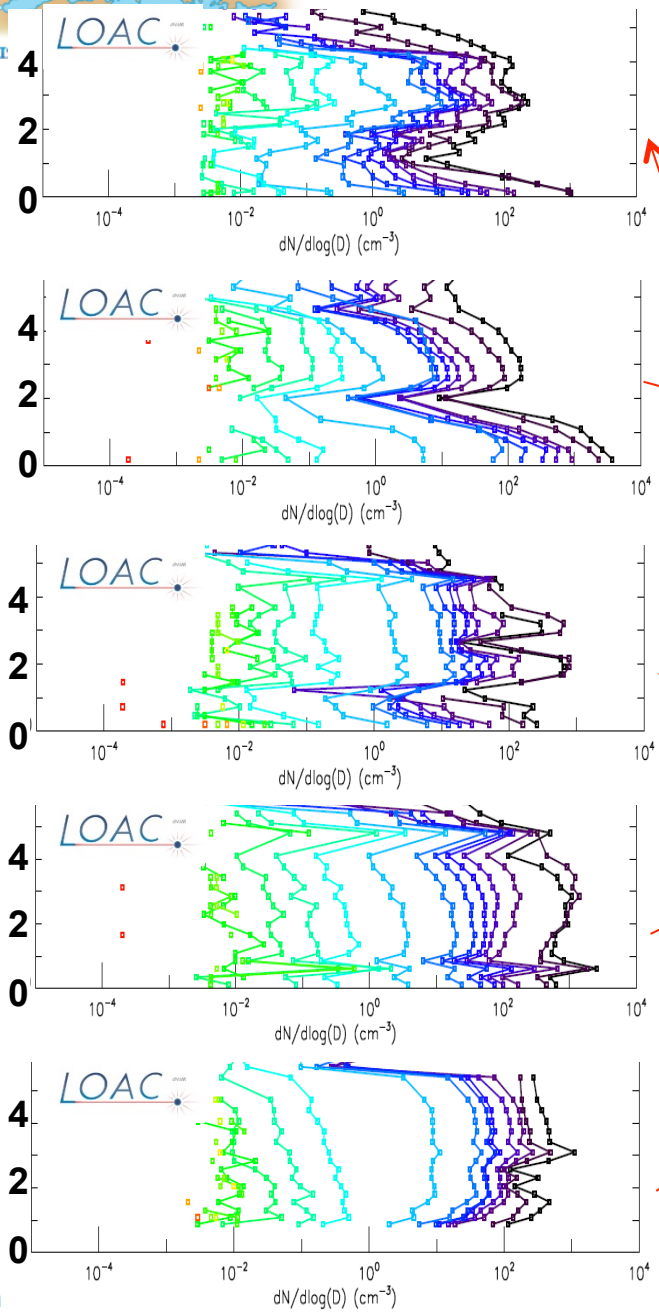
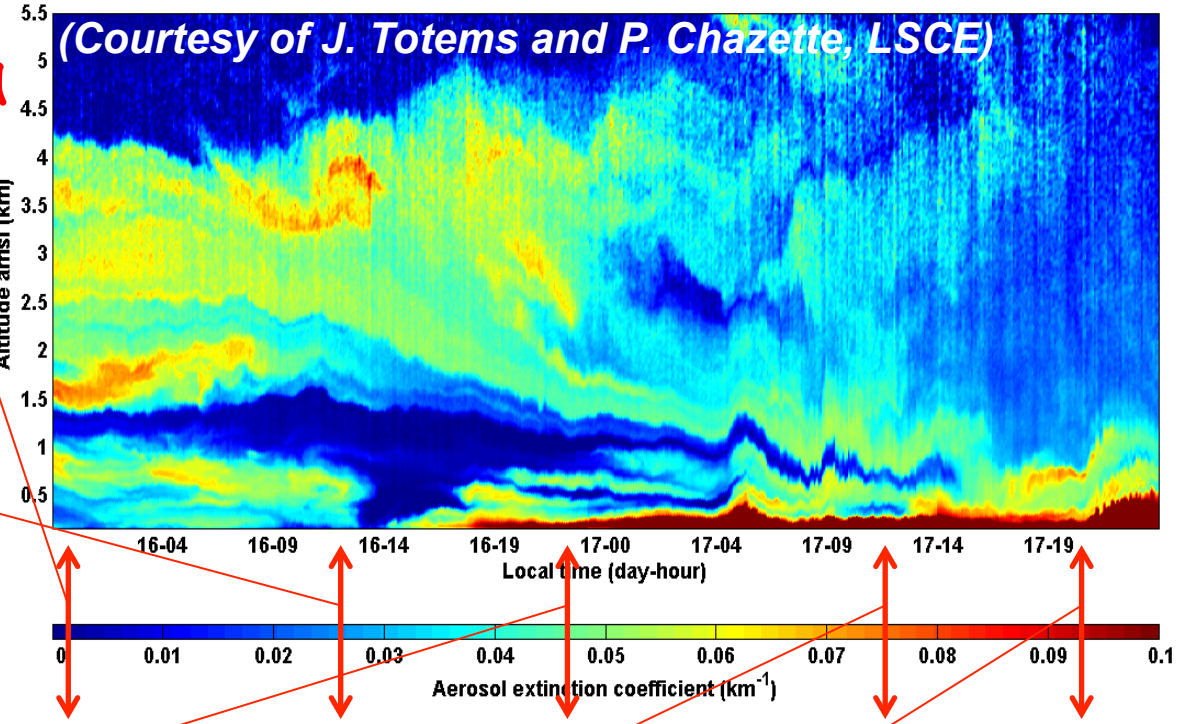
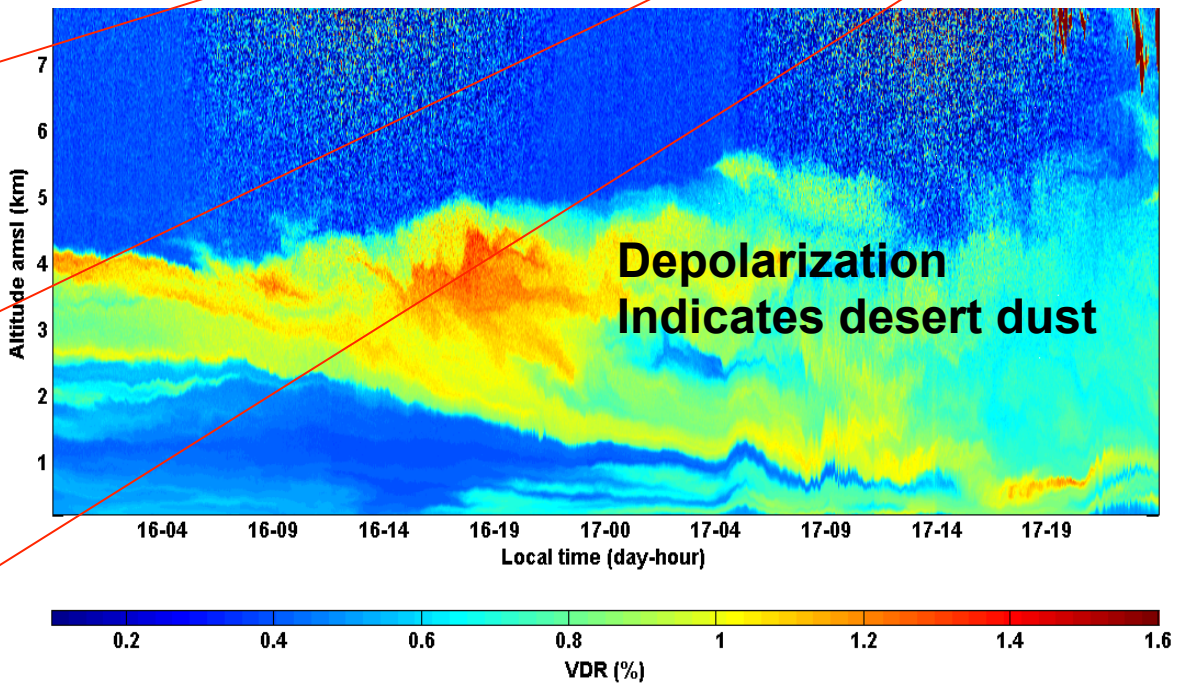
Lidar data



(Courtesy of J. Totems and P. Chazette, LSCE)





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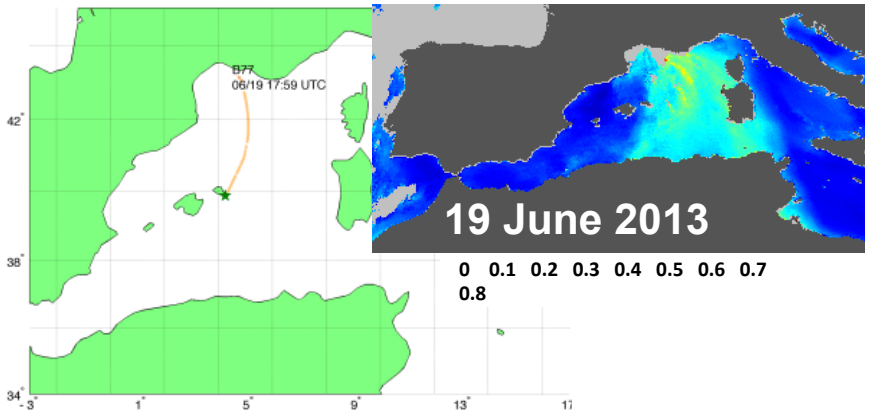
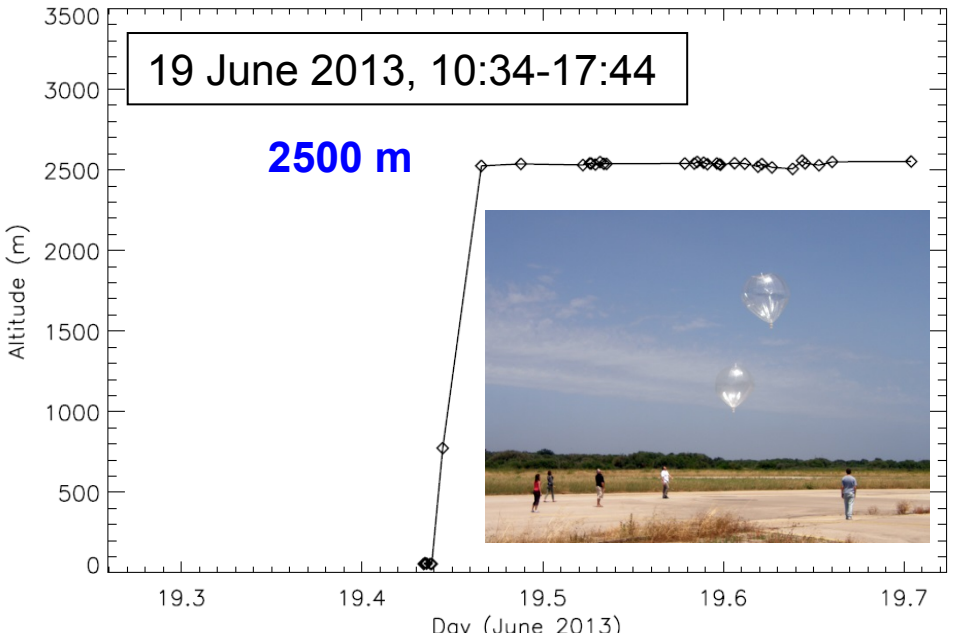
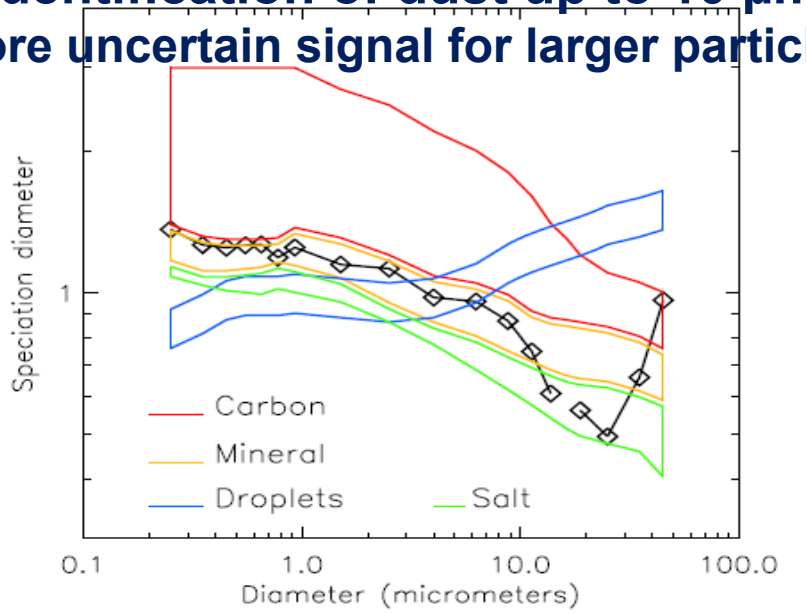
Balloon drift of several hours above the Mediterranean Sea



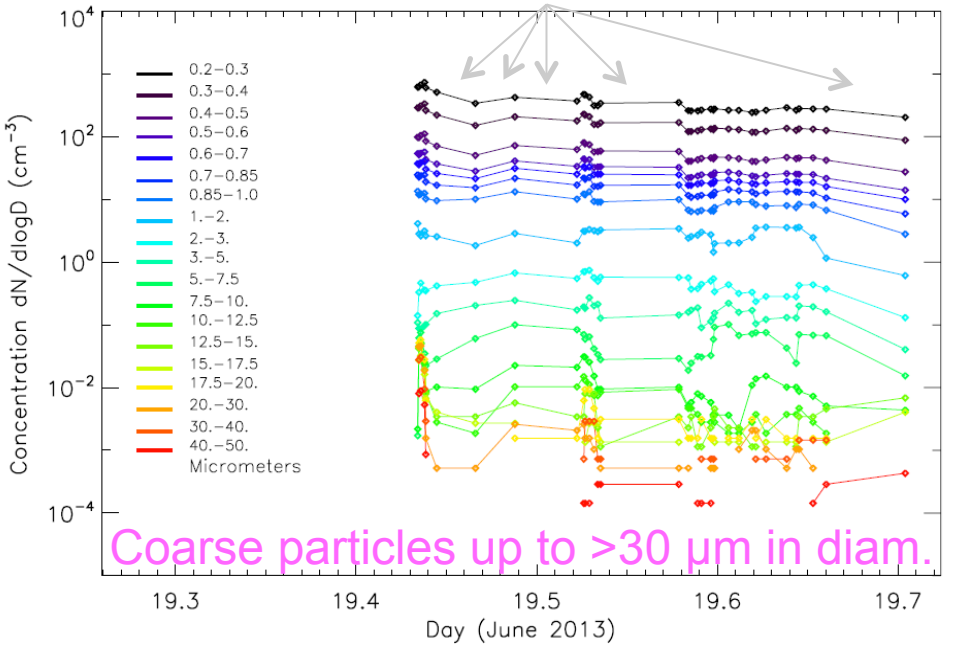


Identification of dust up to 10 µm

More uncertain signal for larger particles

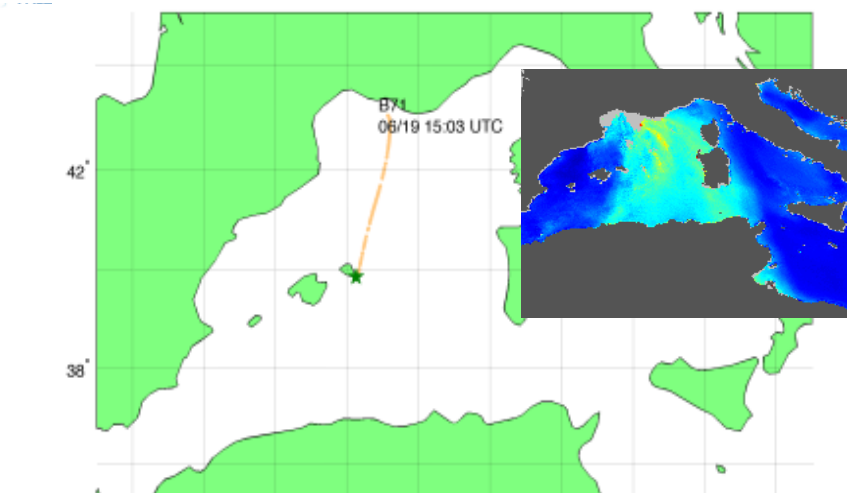


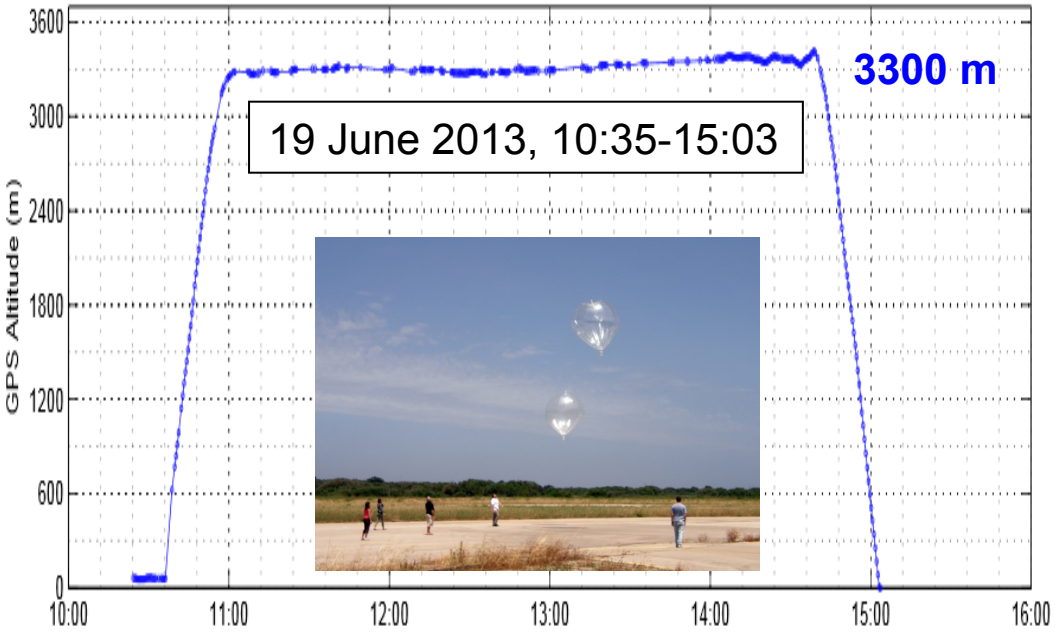
Missing data following satellite transmission problems

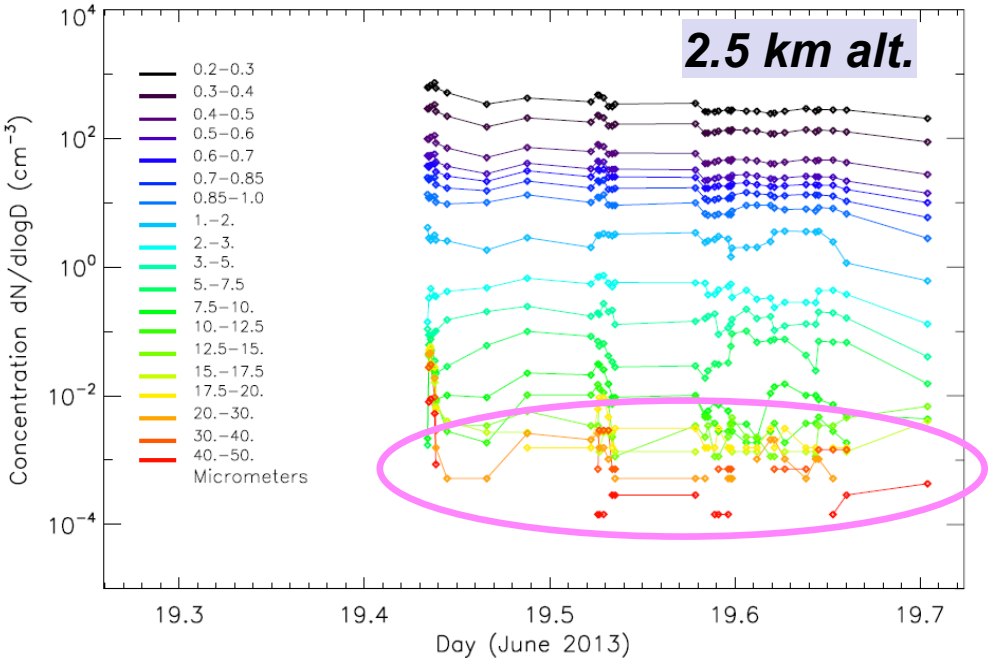


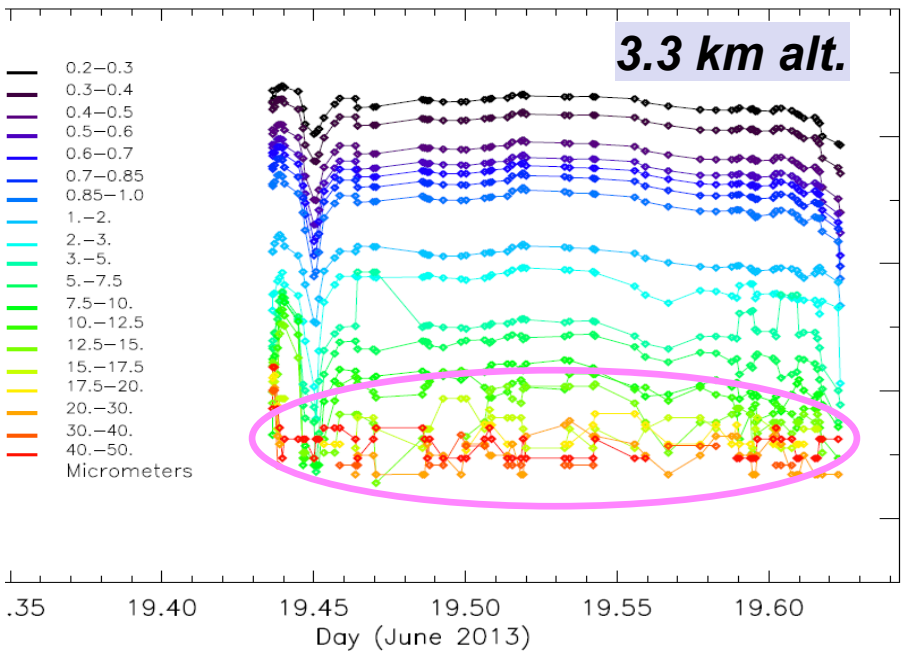
Coarse particles up to >30 µm in diam.

A 2nd drifting balloon at higher altitude on 19 June



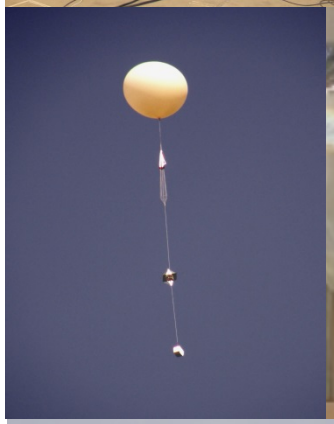




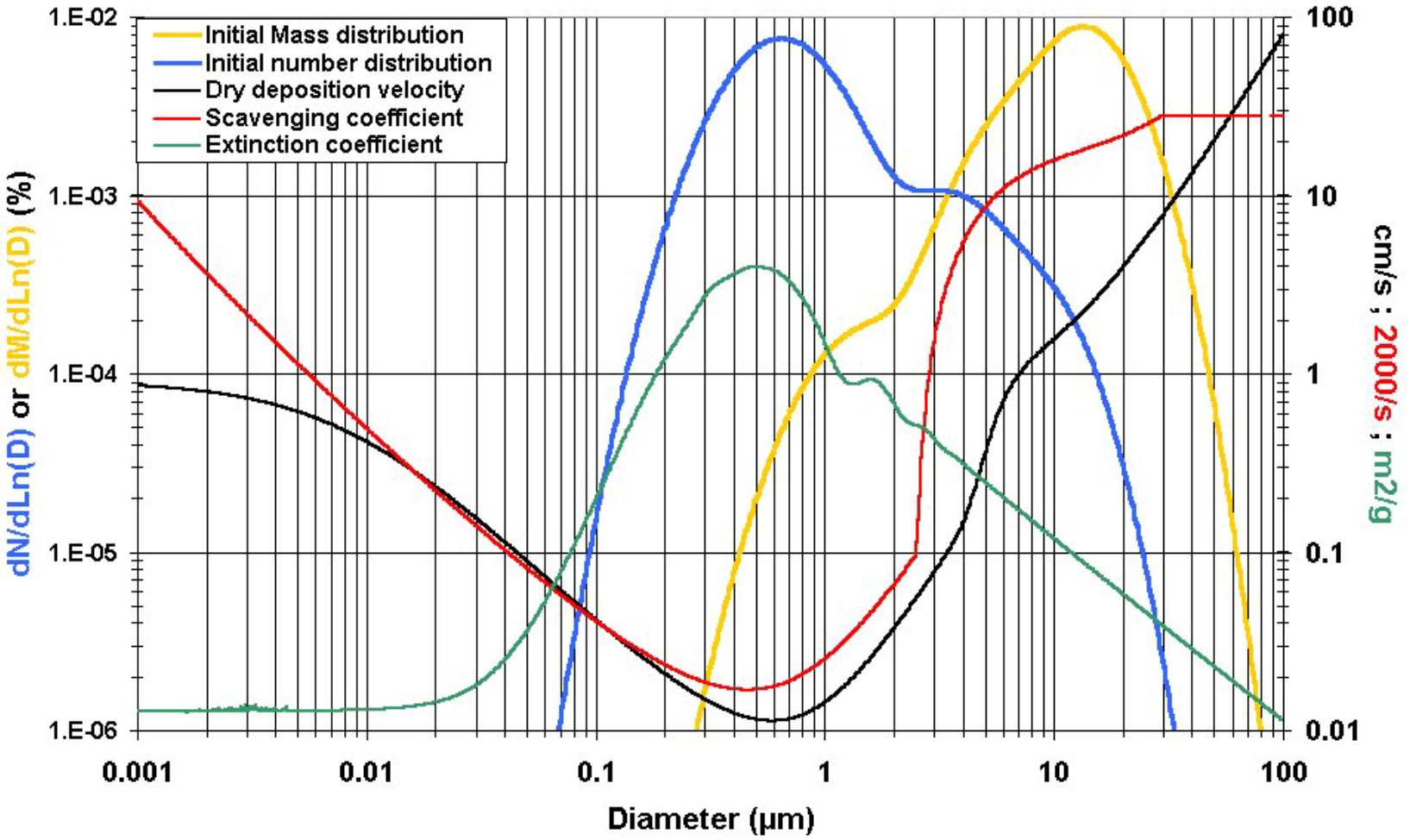


⇨ **Work to be done for a detailed comparison**

Thanks for your attention!



⇨ Particle number, surface or volume/mass control different processes



Cross-comparisons: examples in Ile de France (ParisFog)

⇨ **Many evaluation tests have been performed...**