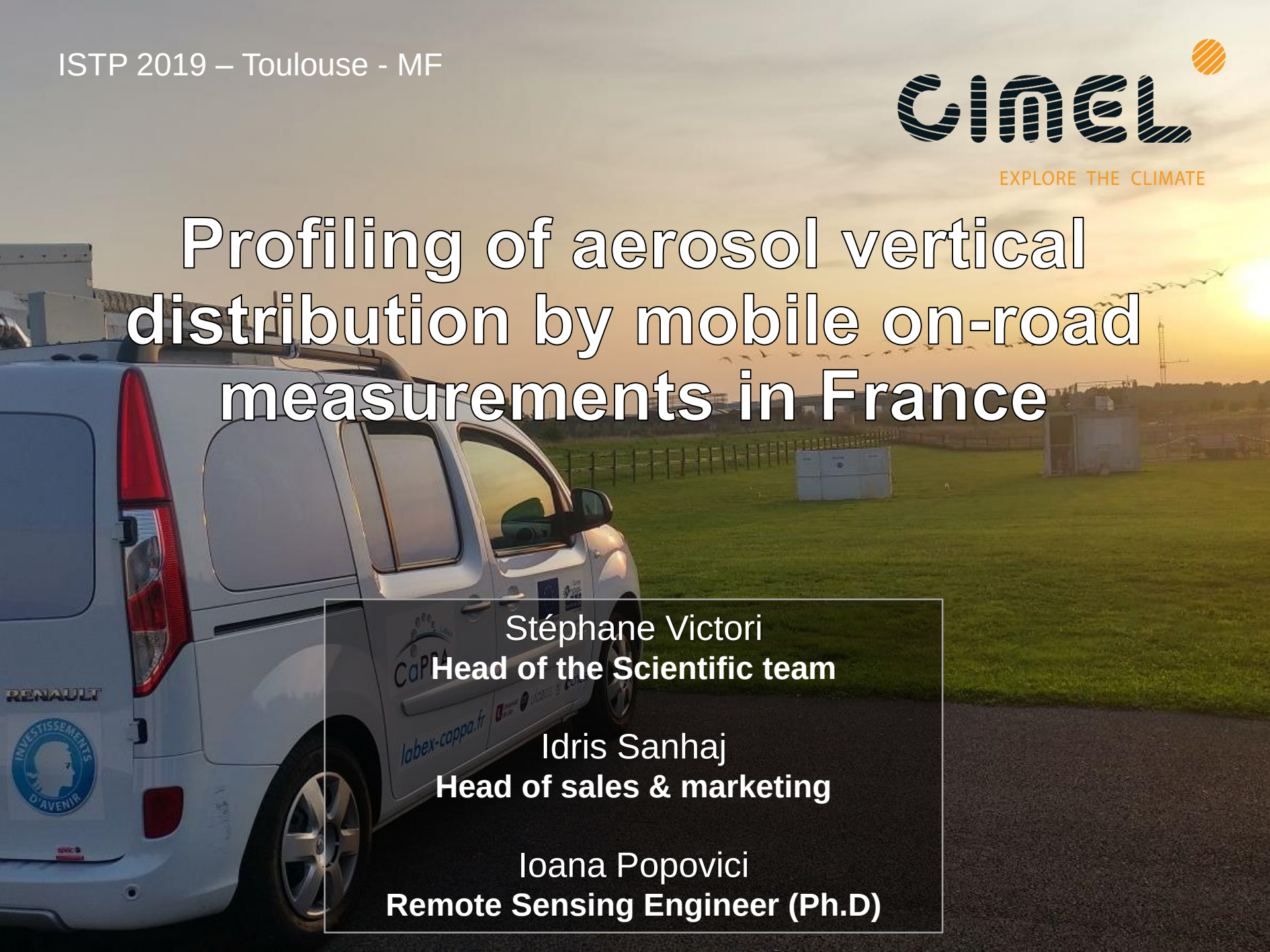
CIMEL

EXPLORE THE CLIMATE

Profiling of aerosol vertical distribution by mobile on-road measurements in France



Stéphane Victori
Head of the Scientific team

Idris Sanhaj
Head of sales & marketing

Ioana Popovici
Remote Sensing Engineer (Ph.D)

Objective:

Build a mobile facility to measure the vertical distribution of the aerosol

➔ **MAMS**

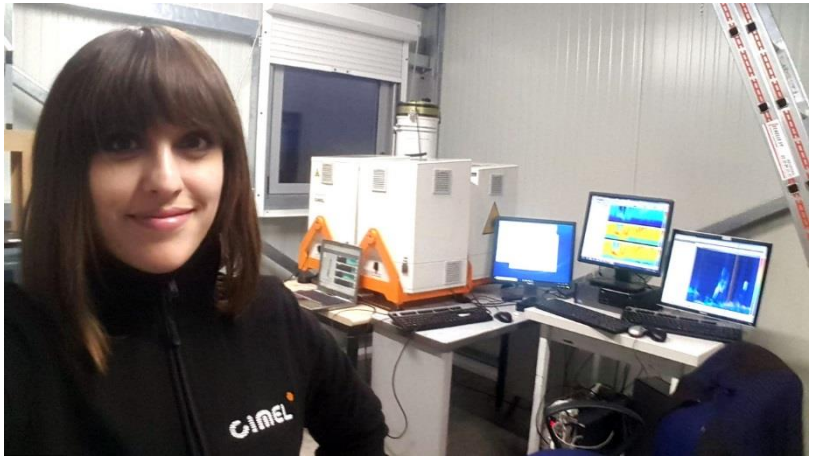
Mobile Aerosol Monitoring System

Ioana Popovici
Remote sensing engineer (Ph.D)

CINEL
EXPLORE THE CLIMATE

ISTP Presentation

Summary



i-popovici@cimel.fr

ioanaelisabeta.popovici.etu@univ-lille.fr

CIMEL
EXPLORE THE CLIMATE

1. Presentation

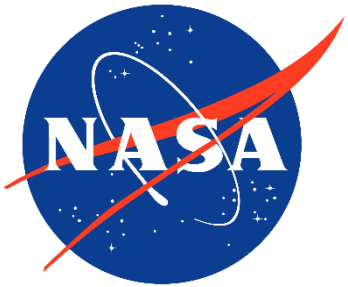
Who we are & What we do…

French manufacturer of meteorological and atmospheric observation systems for all "weather sensitive" activities

Automatic Weather Stations

Remote sensing solutions

Some of our partners…



- Calibration
- R&D lunar AOD
- Data center (operational)

LATMOS

- LiDAR Reference
- Calibration platform

CINEL
EXPLORE THE CLIMATE

- Calibration
- Measurement campaigns
- Data center (operational)

AEMet
Agencia Estatal de Meteorología

- Calibration
- R&D LiDAR bi-λ
- R&D photometer lunar

ACTRiS

2. Products & Applications

CIMEL Website : Remote Sensing instruments

REMOTE SENSING INSTRUMENTS

CE312 - High precision IR Radiometer CLIMAT

The CE312 IR radiometer CLIMAT (*) is the benchmark precision instrument for measurements of spectral luminance in 4 to 6 thermal InfraRed bands. Thanks to differential measurement principle, it performs radiation ...

VIEW

CE318-T - Sun Sky Lunar Multiband Photometer

As the only photometer operated by the AERONET international federation of networks since 1992, the CE318 multiband photometer is recognized as the worldwide reference for aerosol observing networks. The latest version, the ...

VIEW

CE332 - Airborne multiband infrared radiometer

CE332 is a very accurate device for measuring simultaneously an aimed target radiance and brightness over three thermal infrared bandwidths The radiometer is specially designed to be used in mobile ...

VIEW

CE351 - Atmospheric multi-band imager

CE351 imager measures the sky radiance in 6 bandwidths from 406 nm to 628 nm. Its original patented design of its telecentric optics (Fish-eye +/- 92°) ensures an absolute measure with ...

VIEW

CE370 - Long Range Automatic Aerosol LiDAR

Eye safe LiDAR for 24/7 aerosol and cloud monitoring up to the stratosphere The CE370 LiDAR provides continuous high performance measurements of aerosol and cloud spatial distribution on an extended range. It ...

VIEW

CE376 - Compact Automatic Aerosol LiDAR

The CE376 is a compact, eyesafe backscatter LiDAR, featuring outstanding performances for the automated continuous monitoring of aerosols. It operates in the visible (green) and/or in the near infrared (NIR) ...

VIEW

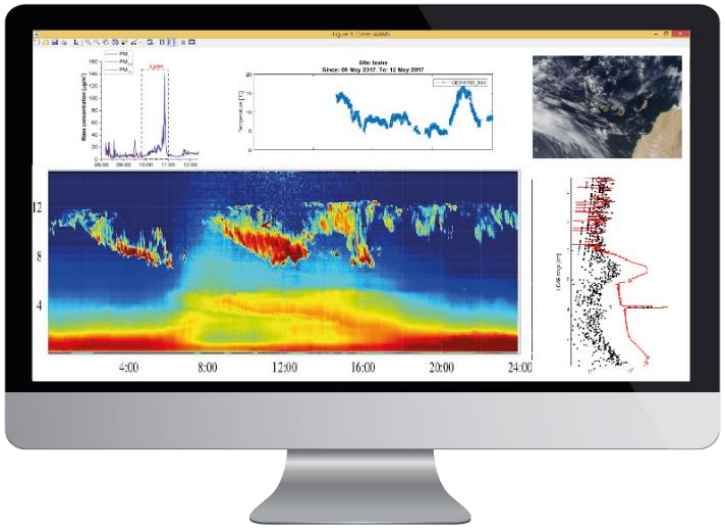
CE600 - Underwater multi-band imager

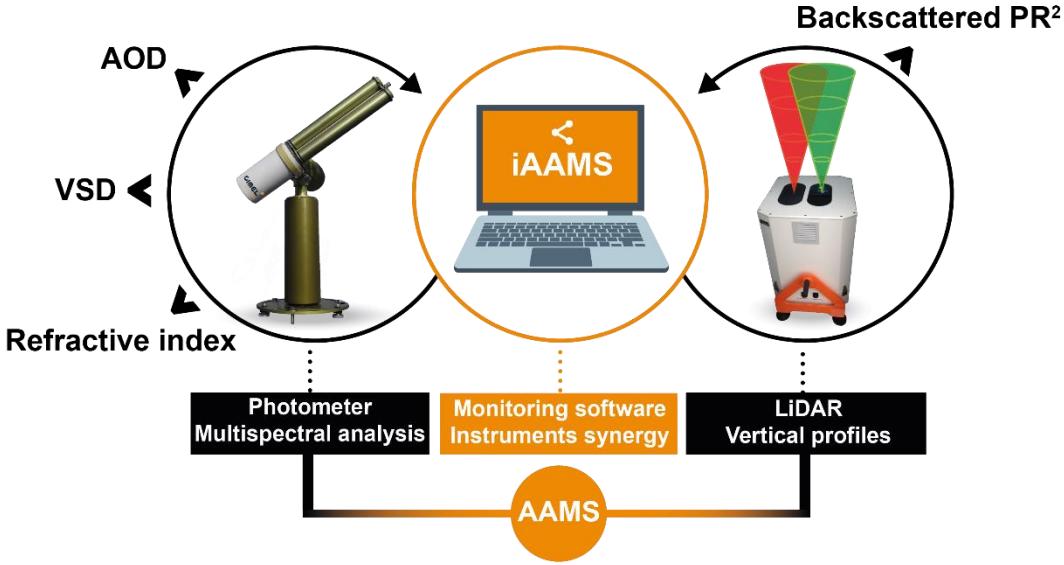
CE600 imager measures underwater multi-spectral radiances in 6 bandwidths from 406 nm to 628 nm. Its original patented design of its telecentric optics (Fish-eye +/- 92°) ensures an absolute measure with ...

VIEW

AAMS: Automatic Aerosol Monitoring Solutions

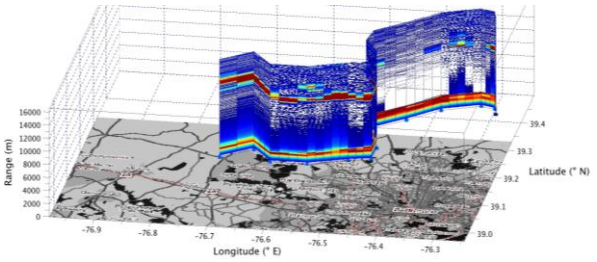
➔ **Synergy between CE318-T & Cimel LiDARs**





- **Continuous measurement (Day & Night)**
- **Real time data analysis**
- **Automatic & integrated system**
- **Easy to install / Mobile**
- **Turnkey solution**

- **Characterization of aerosol types**
- **Vertical profile of Mass concentration**

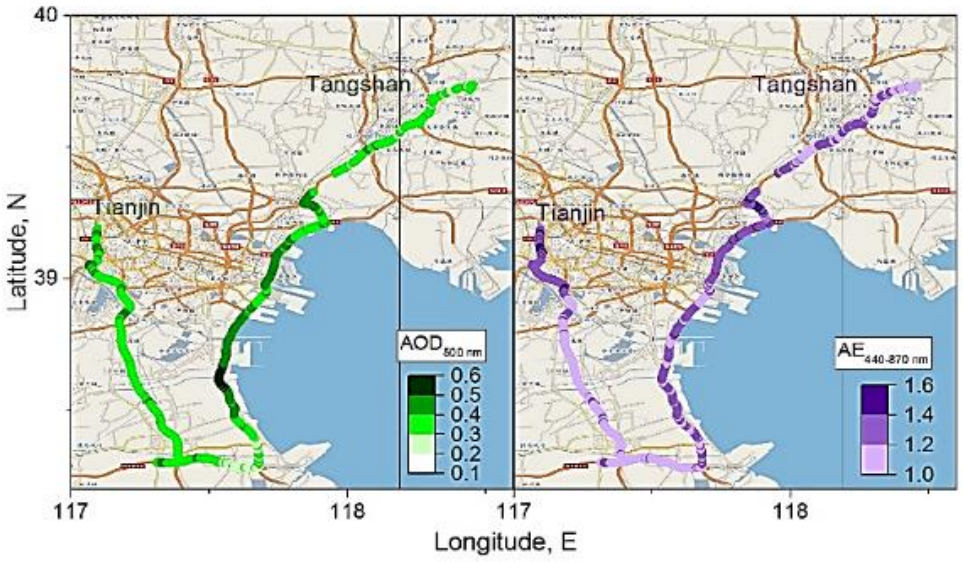


➔ Extinction & Backscatter profiles
3D analysis

CE318-T Photometer in the field

CINEL
EXPLORE THE CLIMATE

3. Mobile observations



Development of a mobile system

- Design and develop a **robust** mobile system for **rapid** aerosol observations
- **Synergy** of remote sensing and in situ measurements
- Retrieve aerosol properties and **air-quality** parameters of interest
- **Mapping** of aerosol spatial and vertical **variability** through on-road measurements
- Show interest for various **scientific questions/applications**, e.g. validation of satellite products and models, use as tool for assessment and warning of hazard events, field campaigns

CINEL
EXPLORE THE CLIMATE

Mobile Aerosol Monitoring System (MAMS)

Instrumental requirements:

- high resolution
- eye-safe LIDAR
- robust
- operational
- autonomous
- reduced size, weight and power consumption

P, T, RH probes

GPS

PLASMA Sun photometers

Isokinetic probe

Aerosol spectrometer (GRIMM mini-WRAS)

CIMEL CE370 LIDAR (532 nm)

Battery

Power inverter

I.E. Popovici et al., AMT, 2018

Resolution:

Vertical (LIDAR CE370): 15 m, range: 200 m – 15 km altitude

Spatial/temporal: PLASMA sun photometer ~ 300 m/10 s
LIDAR ~ 1 km/30 s
MiniWRAS ~ 2 km/60 s

(for 110 km/h)

Autonomy: 29 hours
(100 W power consumption)

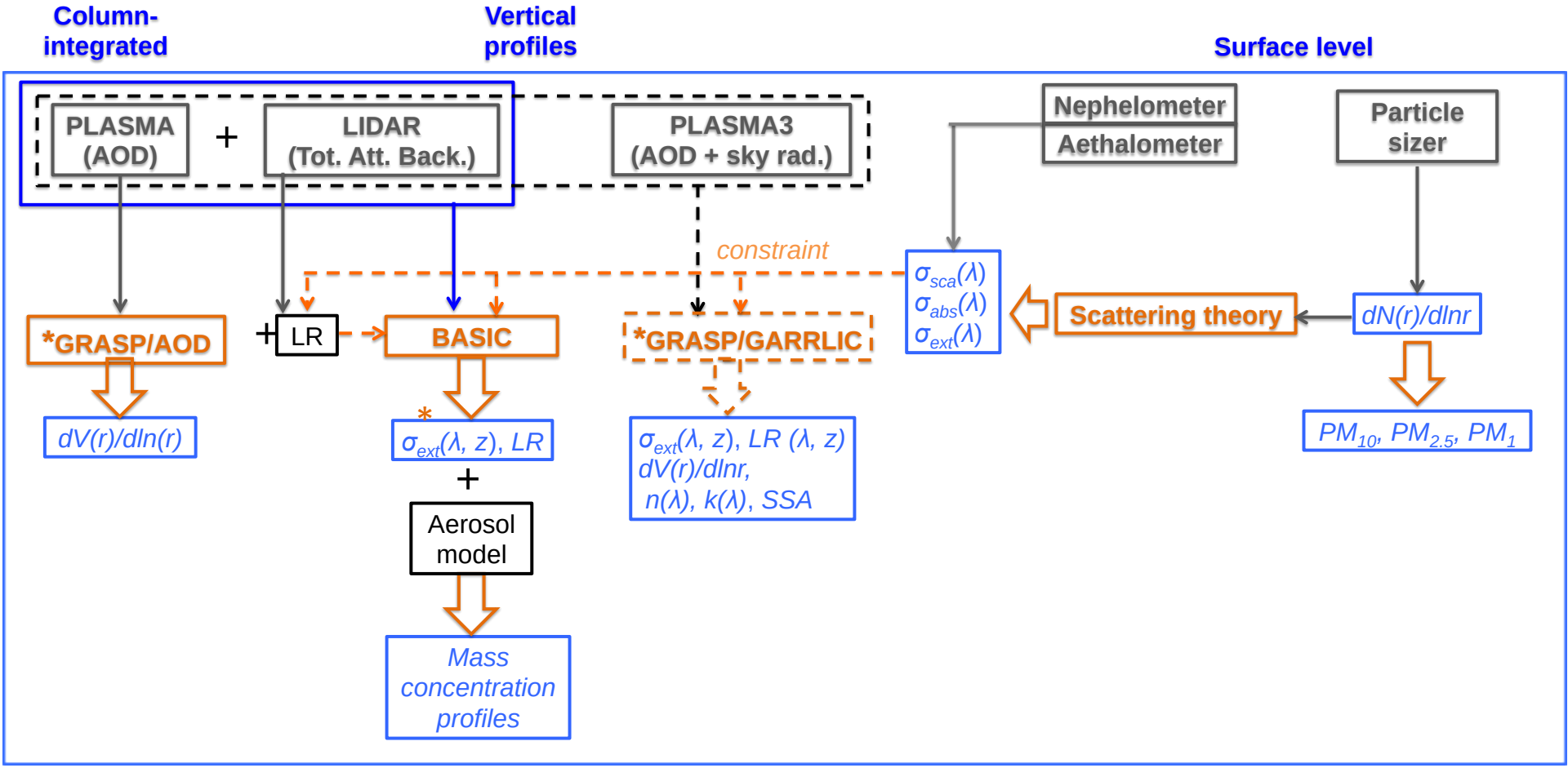
Payload : 130 kg

Cimel CE376 lidar model (532 nm polarized, 808 nm) planned to be integrated in MAMS and tested in motion

*Photomètre Léger Aéroporté pour la Surveillance des Masses d'Air

CIMEL EXPLORE THE CLIMATE

Measured and derived aerosol properties



Legend: Instruments/Measurements | Methods | Aerosol properties

*BASIC – (Mortier, 2013), (Popovici et al., AMT 2018)

*GRASP – Generalized Retrieval of Aerosol and Surface Properties (Dubovik et al., 2011, 2014)

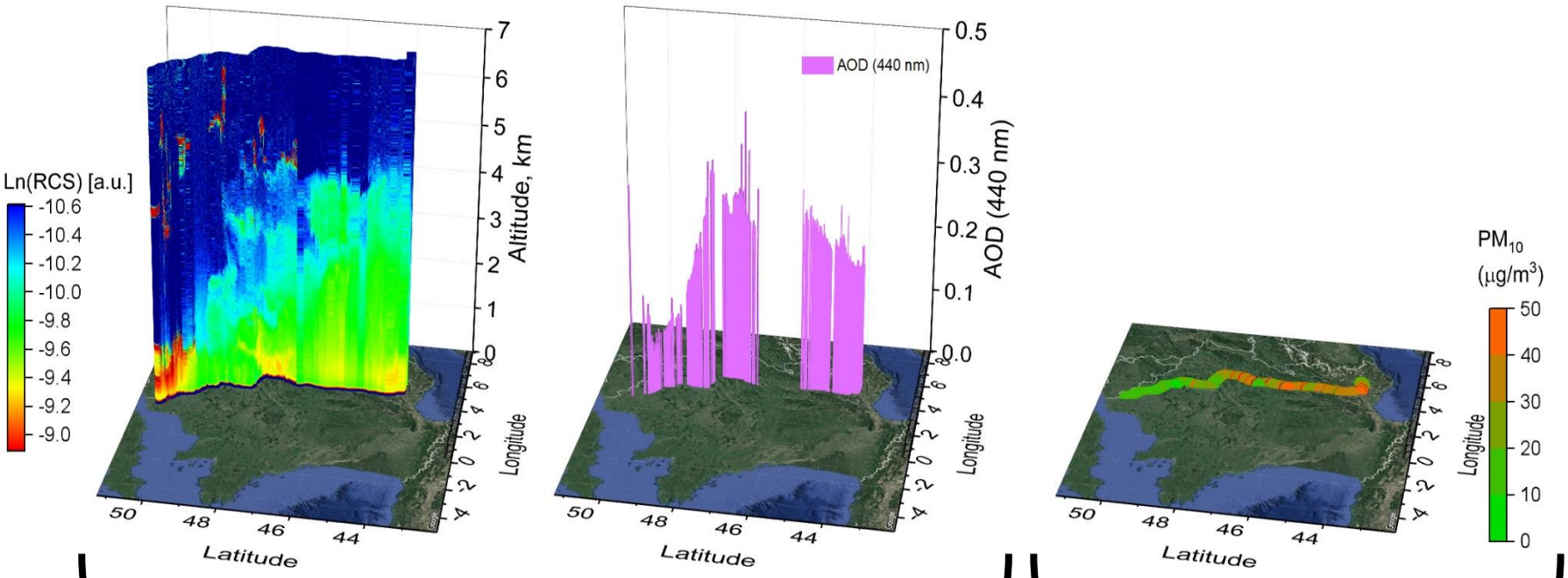
*GRASP/GARRLIC – (Lopatin et al., AMT 2013), *GRASP/AOD – (Torres et al., AMT 2017)

MAMS, mapping aerosol variability at all levels…

Vertical

Columnar

Surface



LiDAR

Sun photometer

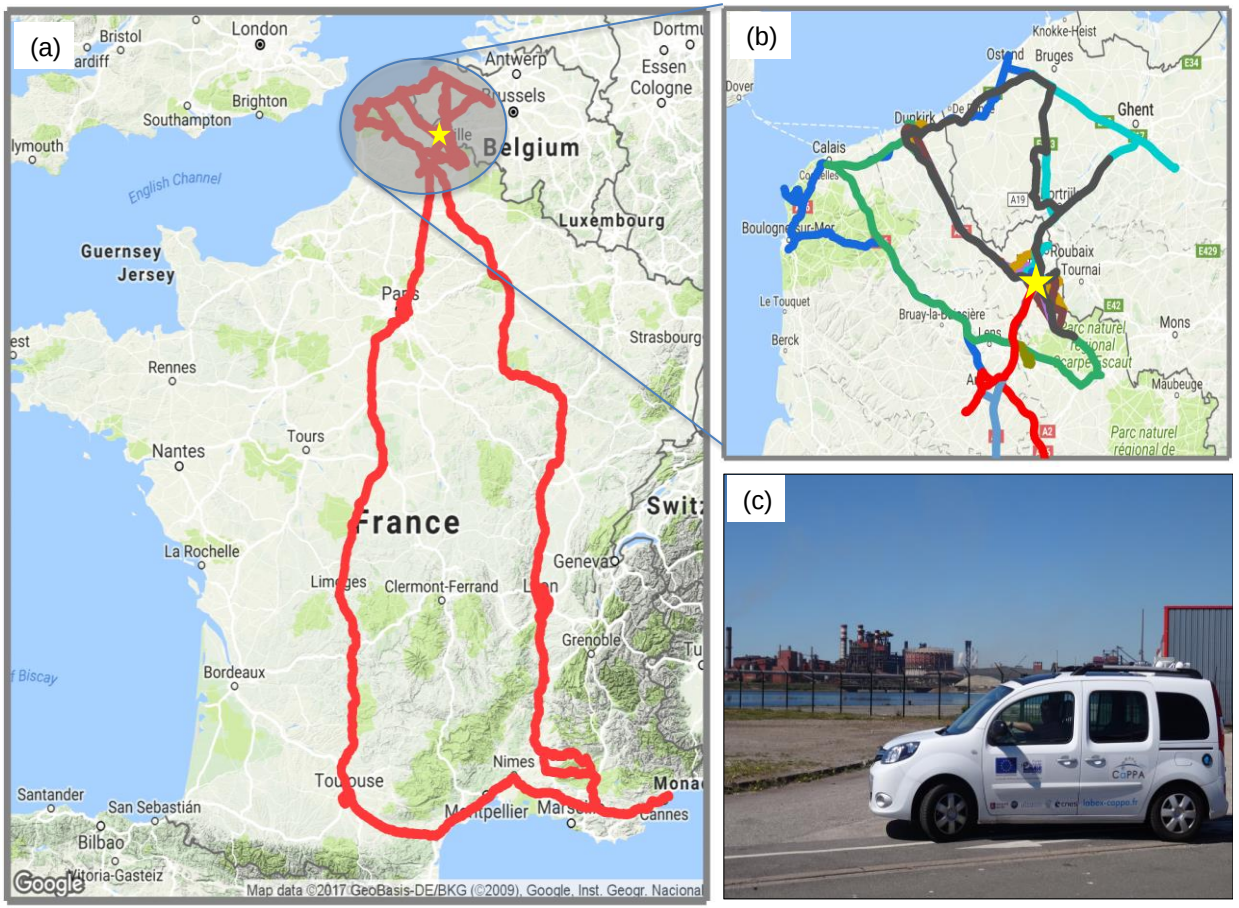
Particle counter

Remote sensing

In situ

CINEL
EXPLORE THE CLIMATE

Aerosol variability in France



- different aerosol situations: **clean, polluted, transport of dust and smoke**
- reveal variability of aerosol properties and extent of pollution events
- **2 long-distance transects** to the South of France
- around **20 mobile campaigns** (2016-2018)

around 1h to be ready for mobile observations

continuous improvement ➔ great robustness and flexibility

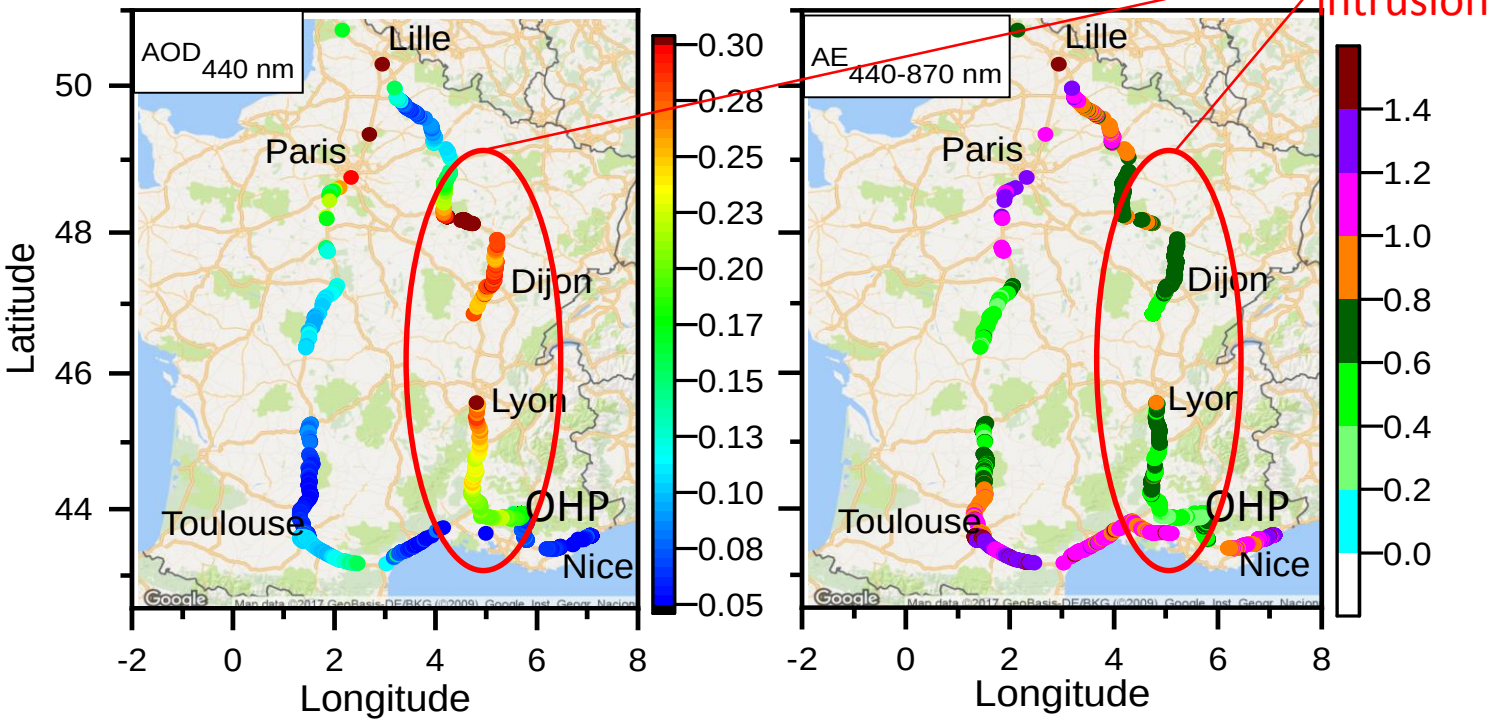
Column-integrated aerosol properties

Case study
3-8 July 2017

Aerosol Optical Depth

Angstrom Exponent

dust intrusion

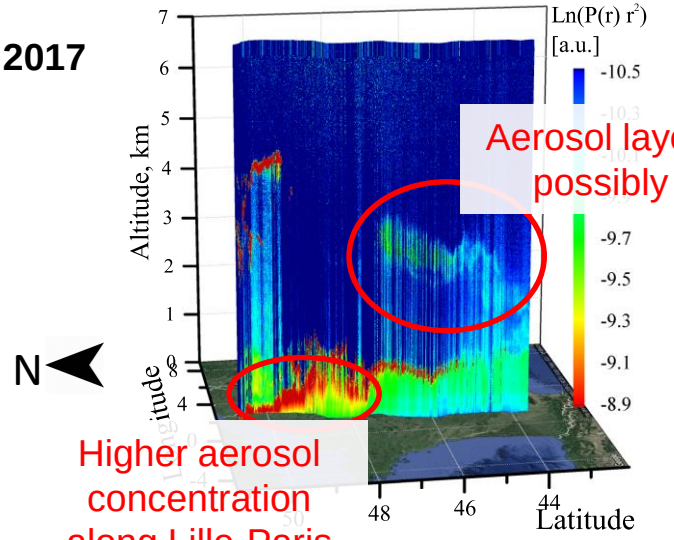


Lille – Toulouse: 0.08 ± 0.04
Toulouse: 0.06 ± 0.01
Toulouse – Nice: 0.08 ± 0.03
OHP – Dijon: 0.22 ± 0.02
Dijon – Lille: 0.21 ± 0.09

Lille – Toulouse: 0.76 ± 0.23
Toulouse: 0.93 ± 0.08
Toulouse – Nice: 1.21 ± 0.18
OHP – Dijon: 0.52 ± 0.11
Dijon – Lille: 0.78 ± 0.14

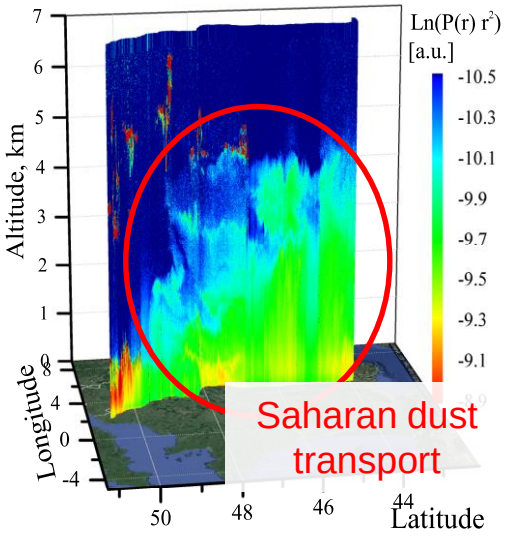
Vertical aerosol distribution

3 July 2017



Aerosol layer at 3 km possibly smoke

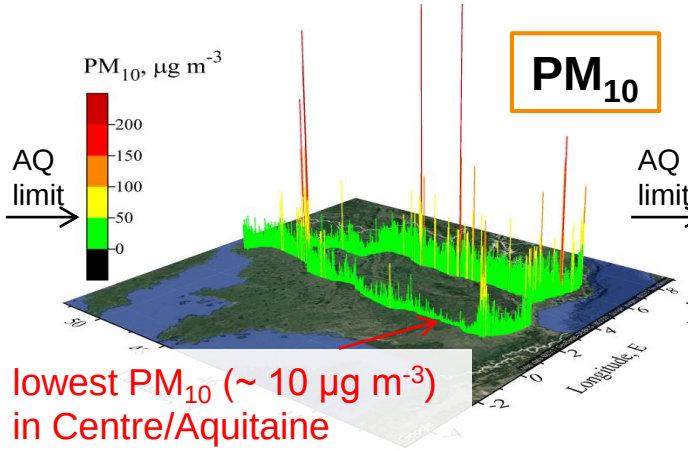
Higher aerosol concentration along Lille-Paris



7-8 July 2017

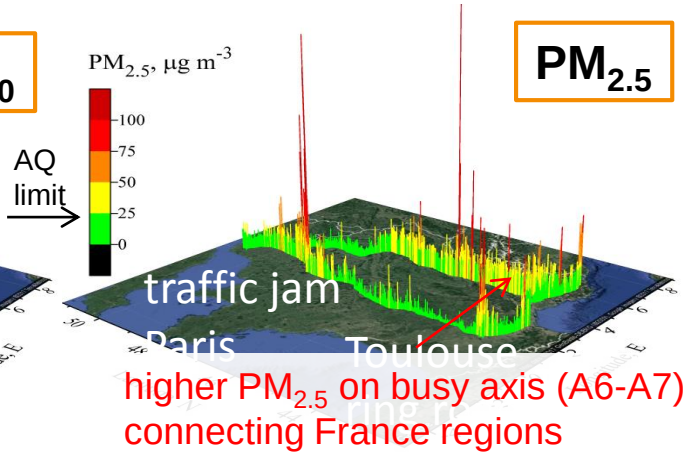
Saharan dust transport

Concentrations at surface level



PM_{10}

lowest PM_{10} (~ 10 µg m^{-3}) in Centre/Aquitaine



$PM_{2.5}$

higher $PM_{2.5}$ on busy axis (A6-A7) connecting France regions

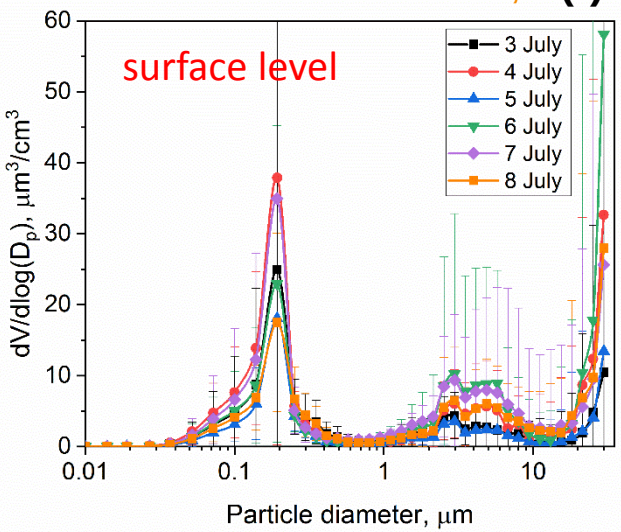
Mass concentration profiles - methodology

$$M(z) = \frac{4}{3}\rho\,\sigma_{aer}(z)\int_{r_{min}}^{r_{max}} \frac{r^3 \cdot n(r)}{\int_{r_{min}}^{r_{max}} Q_{ext}(m,r,\lambda)\cdot n(r)\cdot r^2 dr}\,dr$$

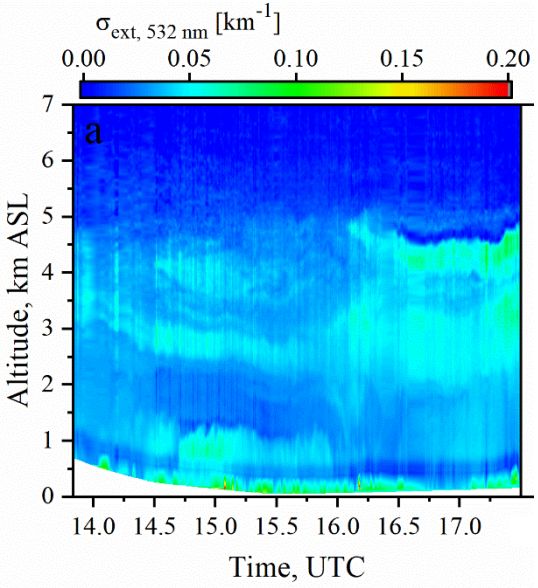
(Mortier et al., 2013)

7 July 2017
Complex case
Multi-layer
aerosol situation

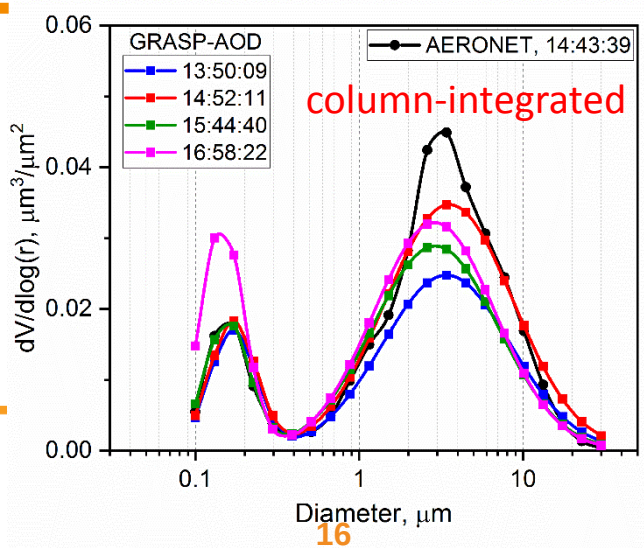
Volume size distribution, **n(r)**



Extinction coefficient profiles, **σ_{ext}(z)**



+



+

Refractive index, **m**
Particle density, **ρ**

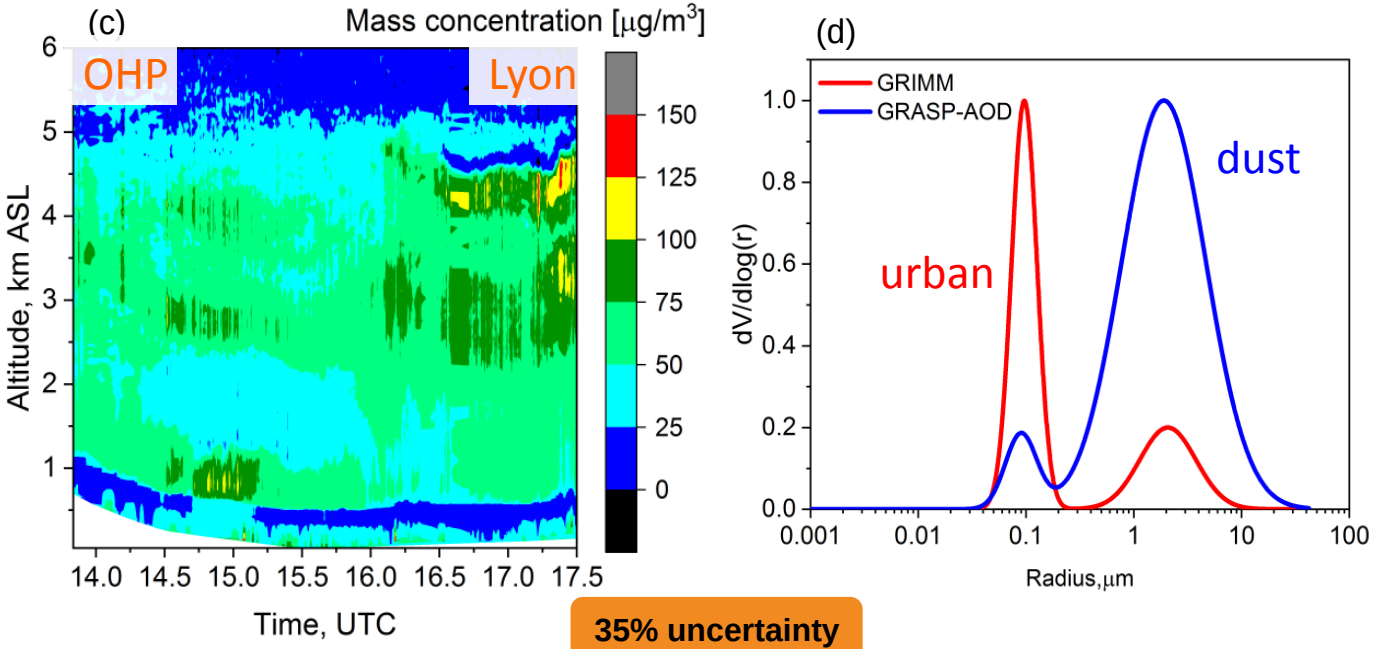
urban/traffic aerosols

$m_1 = 1.53 - 0.01i$
(Skupin et al., 2016)
$\rho_1 = 1.7$ g cm^{-3}
(Hess et al., 1998)

transported dust

$m_2 = 1.53 - 0.008i$
(AERONET)
$\rho_2 = 2.6$ g cm^{-3}
(Hess et al., 1998)

Estimation of aerosol mass concentration profiles



7 July 2017
Complex case
Multi-layer aerosol situation

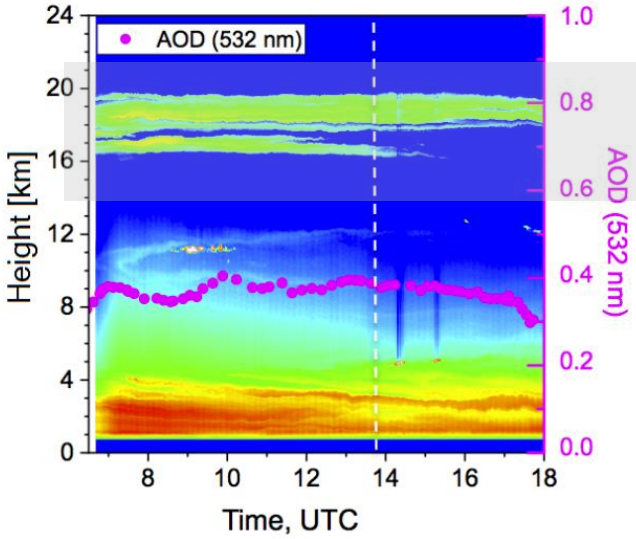
35% uncertainty

- Underestimation of dust layers by **~ 50 %** when using the urban/traffic aerosol model
- Overestimation in the PBL by **~ 50 %** when using the dust aerosol model for whole profile

- **Improved mass concentration when using 2 aerosol models**
- **Aerosol typing possible with the help of 2λ + depolarization (LiDAR)**

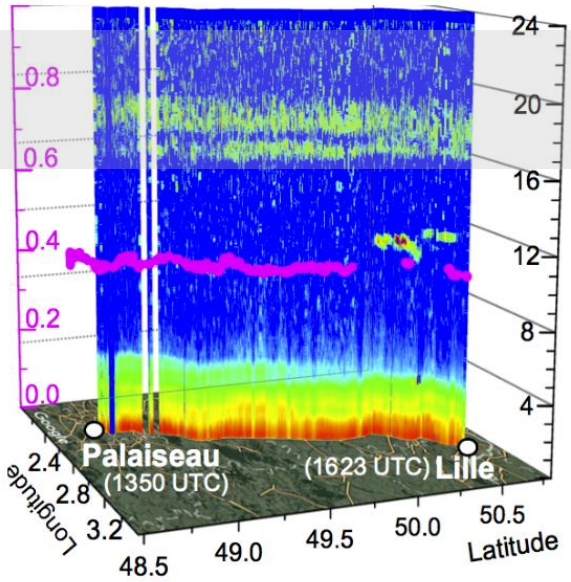
Extraordinary event of stratospheric aerosols

29 August 2017
Challenging situation
High-altitude aerosol layers



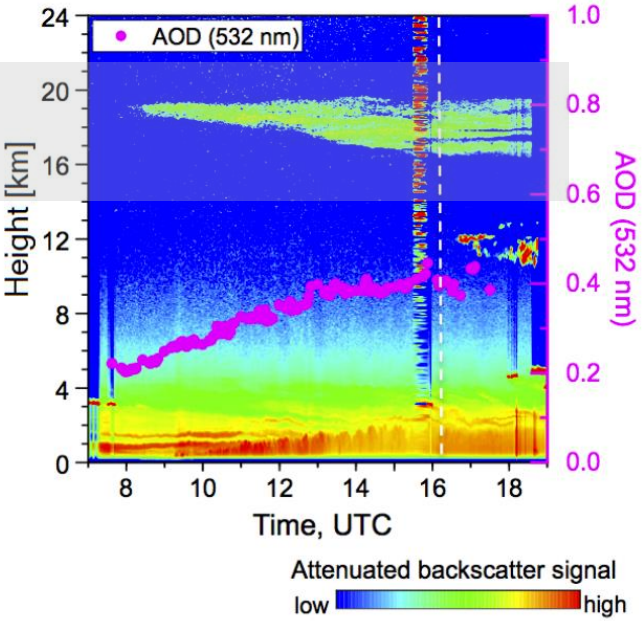
IPRAL (SIRTA/Palaiseau)

Multi-λ Raman lidar
(EARLINET)



MAMS (Palaiseau – Lille)

CIMEL micropulse lidar



LILAS (LOA/Lille)

Multi-λ Raman lidar
(EARLINET)

(Hu et al., ACPD 2018)

smoke layers over France in the low stratosphere (16-20 km)

long range transport from intense Canadian wildfires

$AOD_{layer\ strato,\ 532\ nm} \approx 0.2$

AOD above tropopause : **0.2** – major volcanic eruption, **Mt. Pinatubo**, 1991 (*Ansmann et al., 1997*)
0.005 – **background** conditions (*Renard et al., 2005*)

CIMEL
EXPLORE THE CLIMATE

4. Conclusion

Conclusion & developments

1. Mobile system available for the market
2. Instrumental Synergy (LiDAR + Photometer + in situ + PTU)
3. Great robustness & stability
4. Turn-key solution & Easily deployed (< 1h)
5. Real time analysis (< 1h) using iAAMS and GRASP-AOD
6. Used for intercomparison & calibration campaigns

Developments for mobile application:

1. 2-wavelength LiDAR + depolarization
2. Photometer PLASMA 3 using CE318T head
3. New mobile platforms: ship (Polarstern), airplane, …

Conclusion

Well known in the Scientific Community for our expertise

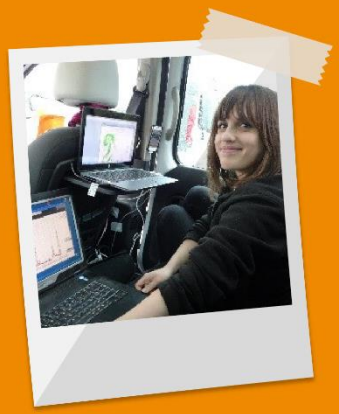
Our **mission** is to be the link between:

Scientific research

Industrial world

Innovative technologies & operational solutions

Thank you!









Idris SANHAJ
Sales & Marketing Director
172 rue de Charonne
75011 Paris, FRANCE
+33 (0)6 45 70 57 69
i-sanhaj@cimel.fr
www.cimel.fr

Stéphane VICTORI, Ph.D
Head of the scientific team.
172 rue de Charonne
75011 Paris, FRANCE
+33 (0)1 43 48 79 33
s-victori@cimel.fr
www.cimel.fr

Thank you for supporting Cimel

Ioana POPOVICI
Remote Sensing Engineer
172 rue de Charonne
75011 Paris, FRANCE
+33 (0)1 43 48 79 33
i-popovici@cimel.fr
www.cimel.fr