# Aerosols Characterization combining Automatic Two-wavelength Polarization Lidar and Sun/Sky/Moon Photometer

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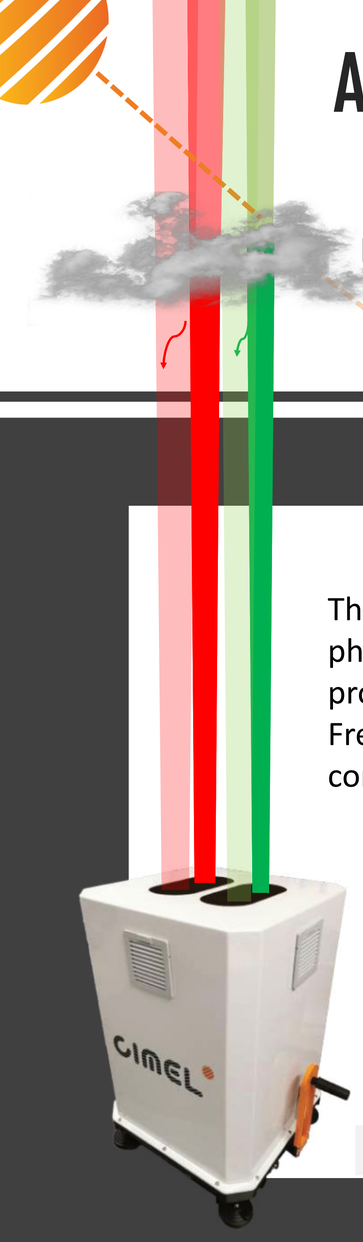



The CE376 micro-pulse lidar and CE318-T sun/sky/moon photometer are integrated for monitoring of aerosols optical properties. Both remote sensing instruments, developed by the French company CIMEL Electronique, operate automatically and continuously.

**CE376 LIDAR**

- Elastic Backscatter signal
- 2 λ: 532 nm and 808 nm
- Depolarization
- 532 nm ∥, 532 nm ⊥

**CE318-T PHOTOMETER**

- Direct sun/moon meas.
- AOD at 9 λ, EAE
- Sky radiance meas.
- Almucantar scenario

**Retrievals**: Backscatter ($\beta$), Extinction ($\alpha$),Volume and Particle Linear Depolarization Ratios ($\delta^v$, $\delta^p$), Attenuated Color Ratio (ACR), Color Ratio (CR)

## Introduction: Lidar-photometer synergetic observations

Quality assessment mostly took place at ATOLL (Atmospheric Observatory of liLLe) platform operated by LOA-University of Lille, France. **METIS**, an early CE376 version, is co-located with CE318-T photometers (AERONET calibration center) and with **LILAS**, a multi-wavelength EARLINET-ACTRIS lidar.

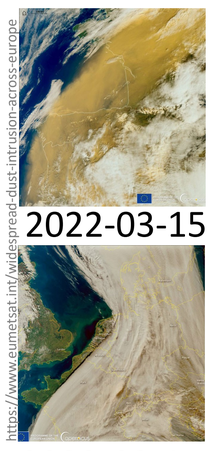
To retrieve aerosols properties, a modified AOD constrained Klett inversion has been developed for simultaneous two-wavelength elastic lidar measurements [1,2,3]. Validation of data and methods are achieved through comparisons of METIS-LILAS retrievals. Both instrumental and algorithmic developments are moving towards near real time monitoring of aerosol properties. Furthermore, the applications for fixed and mobile laboratories are considered.

## Monitoring of aerosols transported over Lille-France

### Multiple episodes of aerosols intrusions in March 2022

*After the Saharan dust outbreak that covered Europe, multiple aerosols intrusions were detected*

Sentinel-3 EUMETSAT

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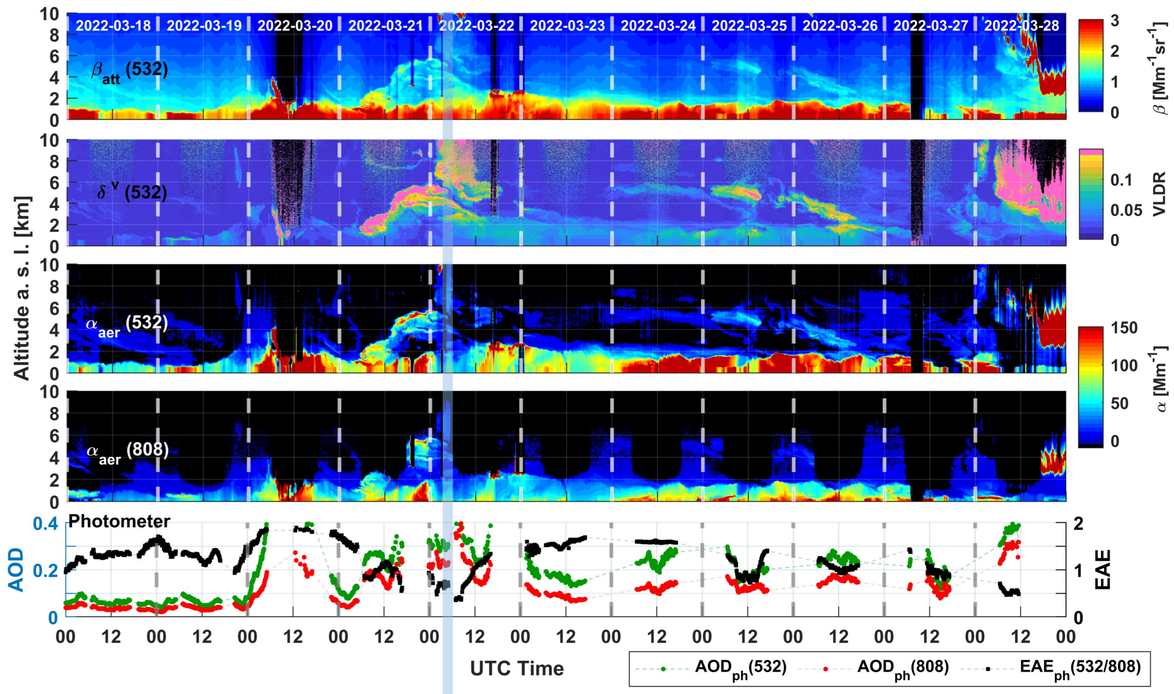
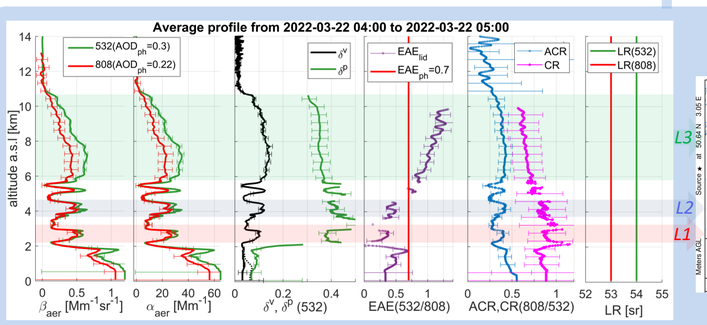
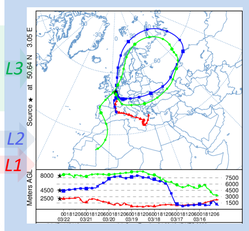



### Multiple aerosol layers up to 11 km!



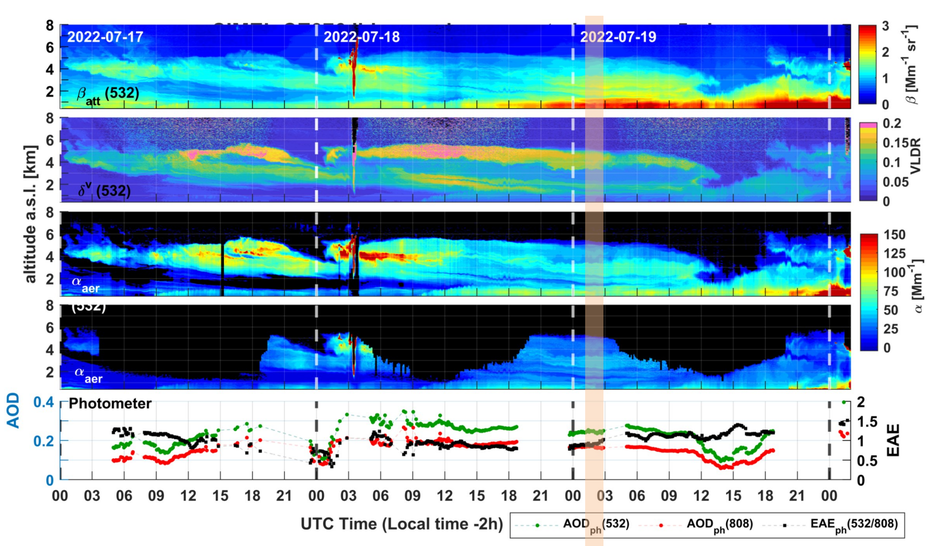




Both L1 and L2 with values of $\delta^p \sim 0.40$ and EAE$\sim 0.25-0.5$ indicating predominance of coarse dust [4,5].

L3 shows slightly decrease of $\delta^p$ $(0.30-0.35)$, ACR, CR and increase in EAE up to 1.5.

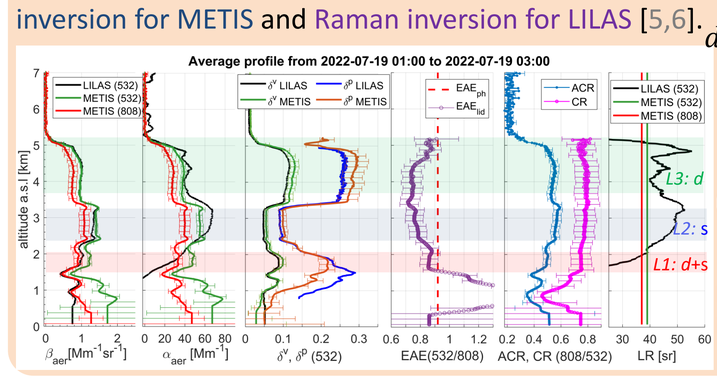
### Extreme heat wave in July 2022

*Dust mixed with smoke from forest fires in the Gironde (SW France)*




### METIS-LILAS comparisons

Optical aerosols properties are retrieved with the modified klett inversion for METIS and Raman inversion for LILAS [5,6]. $d = dust$ s= smoke




We expect:

$$\delta_d^p > \delta_s^p$$

$$EAE_d < EAE_s$$
$$CR_d > CR_s$$

L3: d

L2: s

L1: d+s

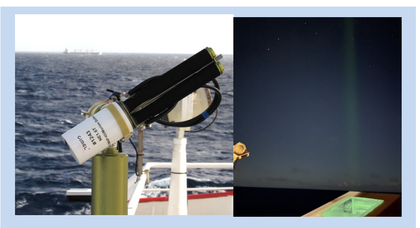
Method limit:
LR vertically constant

## Mobile Applications

***Why mobile measurements using lidar-photometer?***

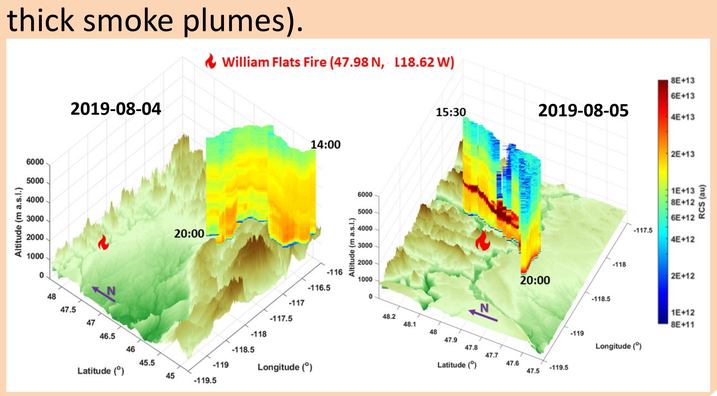
To fill gaps of observations in Monitoring Networks, like over oceans and complex topographies [7,8,9].

+ Use of existing mobile vectors
+ Access to remote areas
+ Ability to get closer to aerosol sources
+ Validation of Satellite in difficult regions



### FIREX-AQ campaign 2019

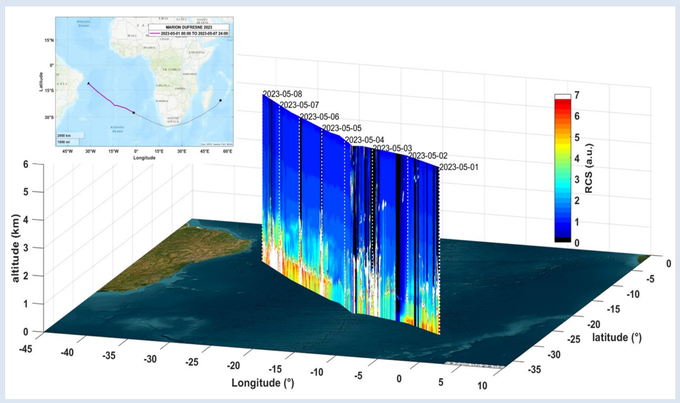
CE376 lidar + CE318-T photometer on board a mobile unit [10,11], performing measurements around the major fires sources. The observations were limited due to harsh conditions of operation (difficult roads, high temperatures, thick smoke plumes).




### TRANSAMA campaign 2023

Mono-wavelength CE370 lidar + 2 CE318-T photometers on board the scientific vessel Marion Dufresne, performing measurements in the Indian and Atlantic oceans.

Installation of CE376 lidar in 2024 (site MAP-IO).




## Conclusions and Perspectives

Continuous and mobile monitoring of aerosols optical properties are achieved with the combination of automatic 2 wavelength and depolarization lidar and sun/sky/moon photometer. Careful evaluation of retrievals and instrument performances have been done. Moreover, retrieved properties are quite consistent with existing literature and validated by comparisons to high power lidar. Ongoing work involve the application of more elaborated joint retrieval (GRASP-GARRLIC).

In the future, in the frame of MAP-IO, OBS4CLIM/ACTRIS and Polar-Pod projects, CE376 lidars will be in operation to monitor aerosol properties in unexplored areas impacted by climate change.

## References

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