Remote sensing solutions for mobile observations

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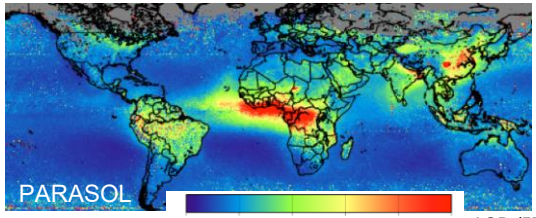
Workshop on "Recent advancements in remote sensing and modelling of aerosols, clouds and surfaces", May 22-26, 2023

Context

Satellite measurements



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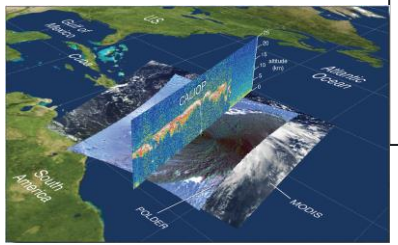

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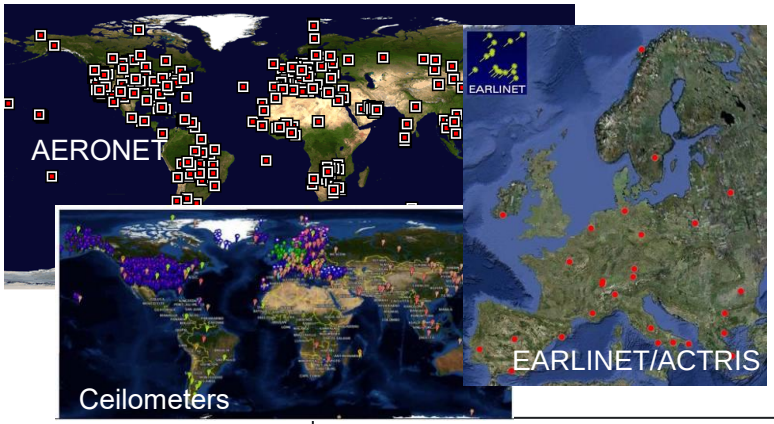
Global *coverage, but limited spatial and temporal resolution*

Ground-based networks



Long term observations, used for climatological and trend studies, but limited to ***fixed locations***

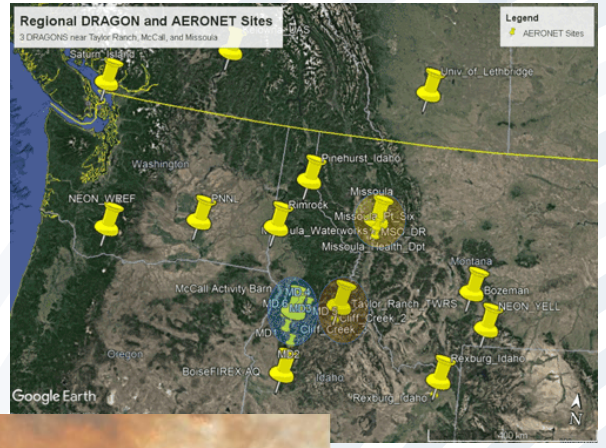
Field campaigns

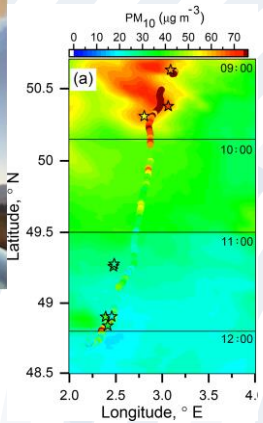
Expensive, require permissions, long to organize; address ***specific issues****, over certain* ***regions***

AGORA Lab

Why mobile observations?

- Complete the observational gaps (land, ocean, air)
- Better coverage over the oceans using existing fleet
- Fast response (dedicated mobile platform)
- Satellite CAL/VAL over oceans and over difficult accessible regions (mountains, volcanoes etc.)
- Study at small scales (city, street, region, emission sources)
- Easy use of active remote sensing (LIDAR) to profile the atmosphere in different points





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Mobile observations strategy

AGORA-Lab

- Observations during the vector's movement
- Movement type: slow (<12 m/s)
- Movement type: fast (aircraft, high-speed train)
- Automatic instruments
- Near Real-Time (NRT) measurements
- AERONET compatible: AOD (sun, moon), radiances
- Modular, standard concept → network objective
- Easy deployment

TGV

SAFIRE

Polar POD

Marion Dufresne

MAMS

AGORA Lab

Mobile observations capabilities

MAMS (Mobile Aerosol Monitoring System)

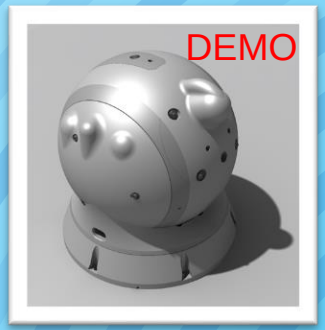
- 1 wl elastic LIDAR (532 nm)
- PLASMA photometer
- Particle counter
- LIDAR-photometer-in-situ synergy

(Popovici et al., AMT, 2018)

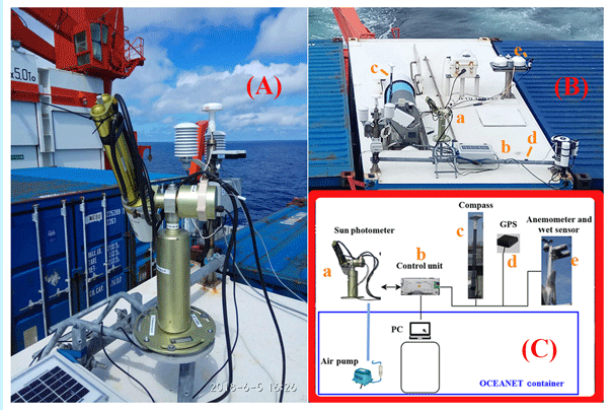
PLASMA photometer

(Karol et al., AMT, 2013)

Advanced PLASMA



CIMEL CE318-T shipborne photometer

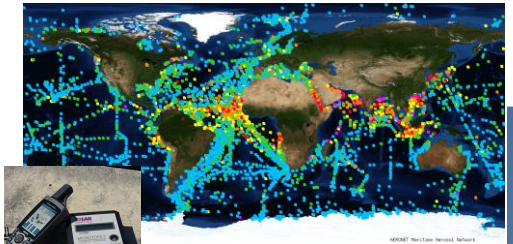


(Yin et al., AMT, 2019)

CIMEL CE376 LIDAR

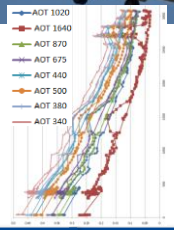
- 2 wl elastic LIDAR (532/808 nm) + depol

Mobile photometer developments



MAN Network
(AERONET)
Microtops

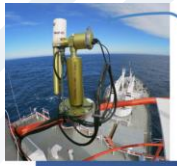
PLASMA 2
FALCON 20



CE318-T
RV POLARSTERN

MOSAIC/Arctic
CE318-T

Sea2Cloud
New Zealand
CE318-T

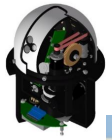


Marion Dufresne
CE318-T

+ SKY Radiances
+ MOON

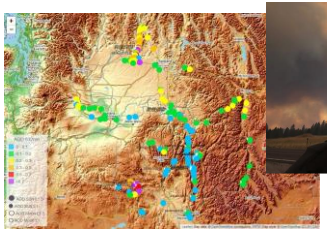
2004 | 2013 | 2017 | 2017 | 2018 | 2019 | 2019 | 2020 | 2020 | 2021 | 2021 | 2022 | 2023

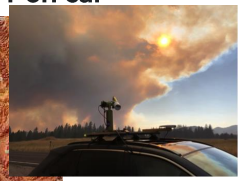
PLASMA 1
(dev. LOA)
Aircraft, ULM, car



AQABA campaign
CIMEL CE318
RV Kommandor Iona

FIRE-AQ
campaign
CE318-T on car





CE318-T
Boulogne sur Mer
GPS improvement

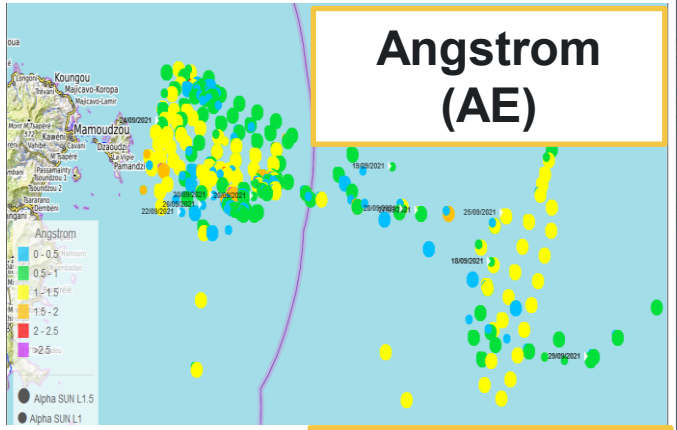
Hybrid Plasma/CE318-T

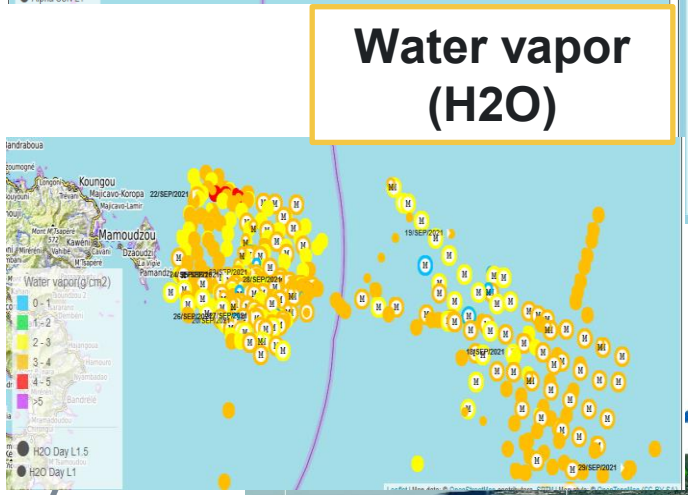
AMARYLLIS
campaign
CE318-T/
Advanced PLASMA

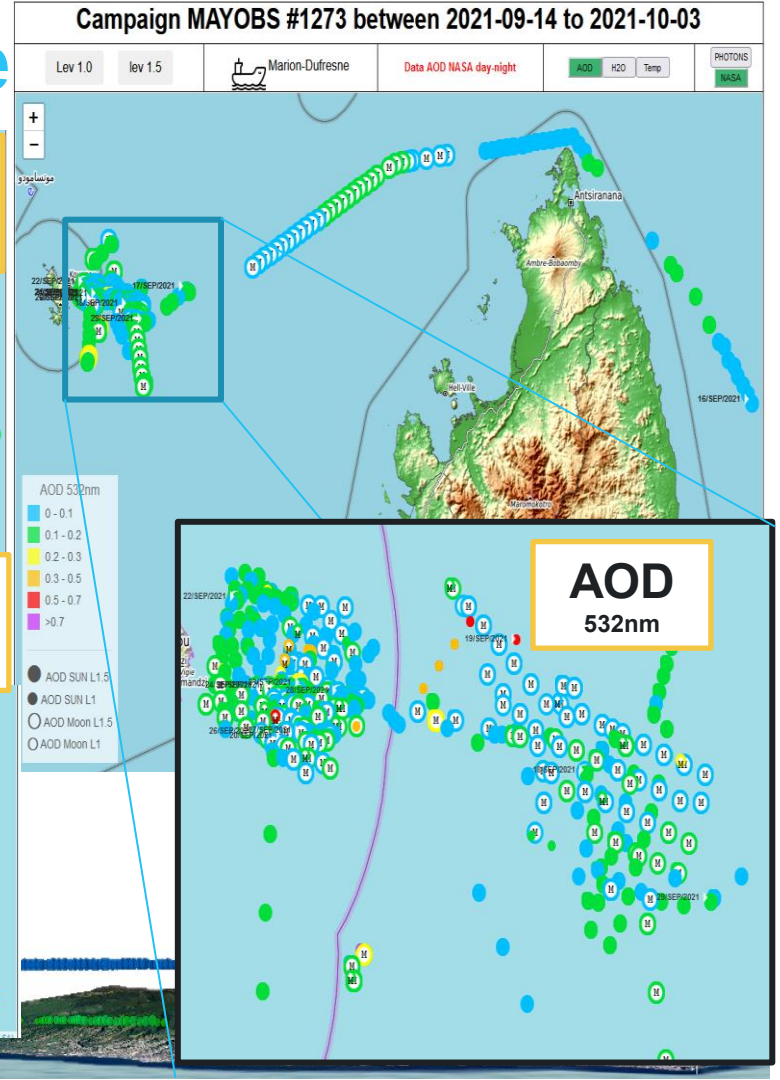
CE318-T on Marion Dufresne

- Photometer in permanent operation since 2021, continuous, without any problems

QA4EO project







Advanced PLASMA (version 3)

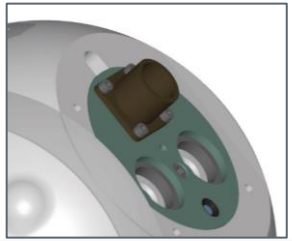
- Compact / Waterproof / GPS inertial unit
- 100% AERONET Compatible
- AOD uncertainty = AERONET master
- Easy maintenance
- Application of GRASP-inversion

CE318T photometer head

+

Plasma1/2

Artist view Rodrigue LOISIL

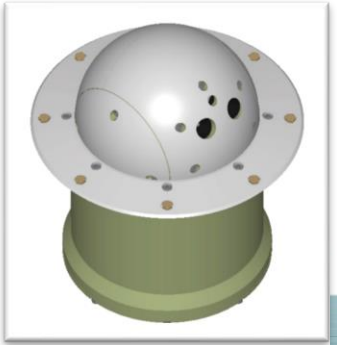


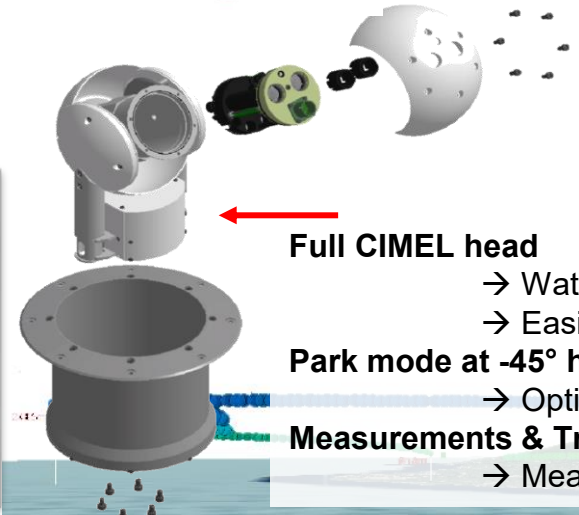
Expected measurements:

- AOD for the 9 standard filters (1640, 1020, 870, 670, 500, 440, 380, 340, 940)
- SKY measurements of almucantar type with option for some filters
- Possibility to perform AOD measurements at certain wavelengths, to accelerate the acquisition
- Night-time AOD measurements

esa

Advanced PLASMA Final Version





Full CIMEL head

→ Waterproof guarantee

→ Easily interchangeable

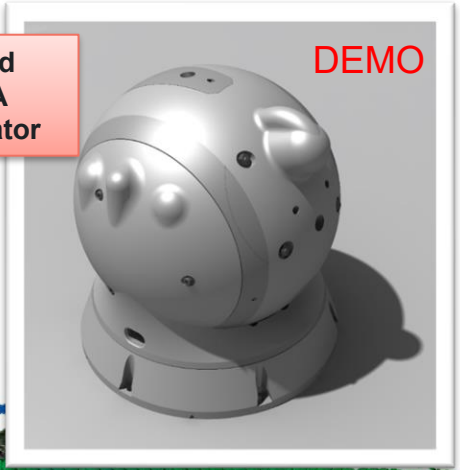
Park mode at -45° horizontal

→ Optics protection

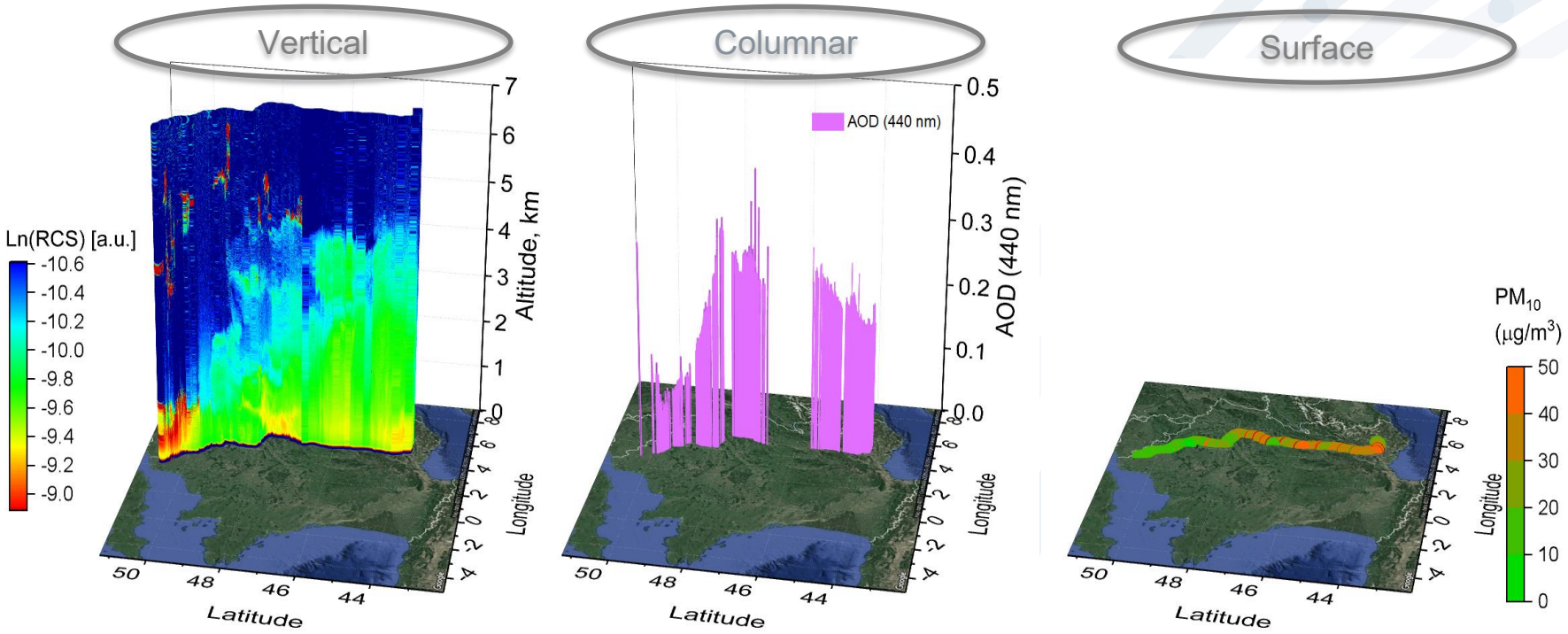
Measurements & Track: Horizon 0° to 0°

→ Measuring range = 360°

Advanced PLASMA Demonstrator

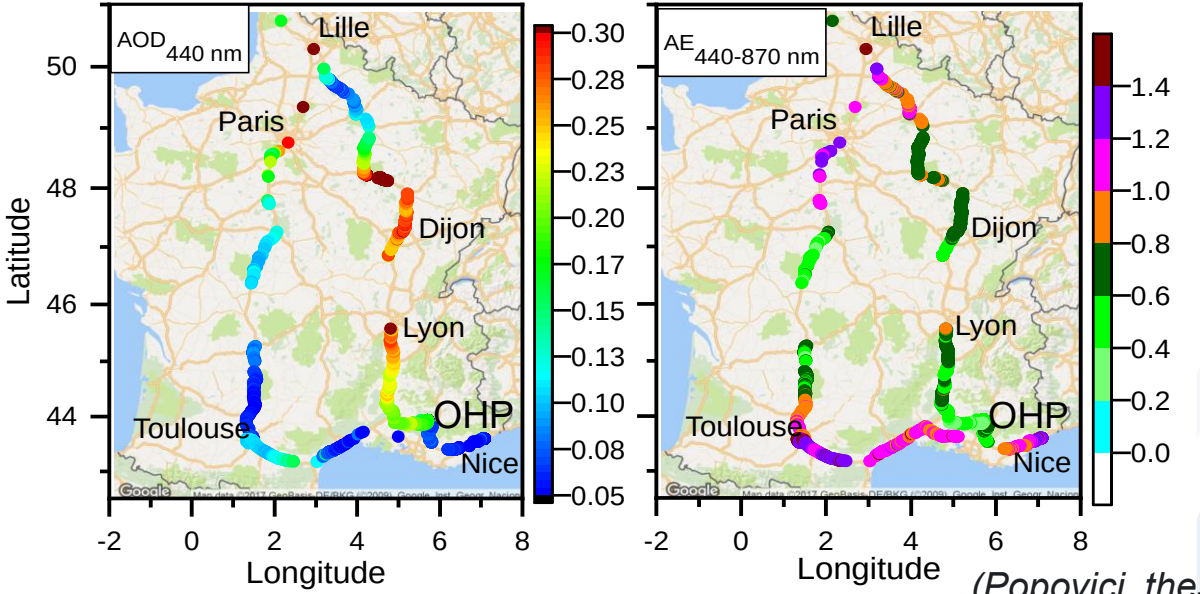


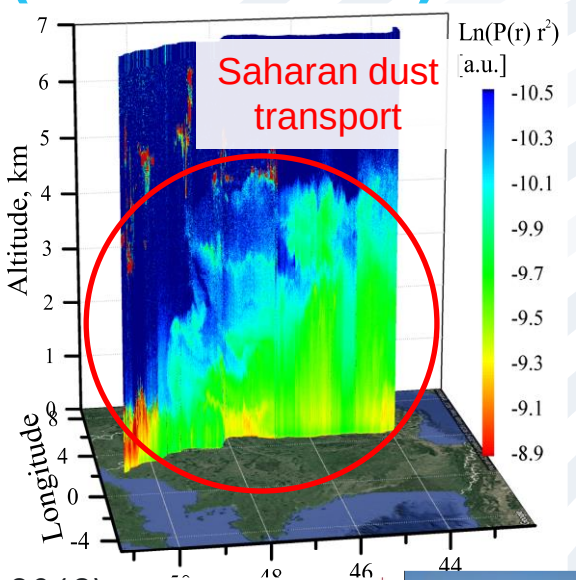
Mapping aerosols variability at all levels



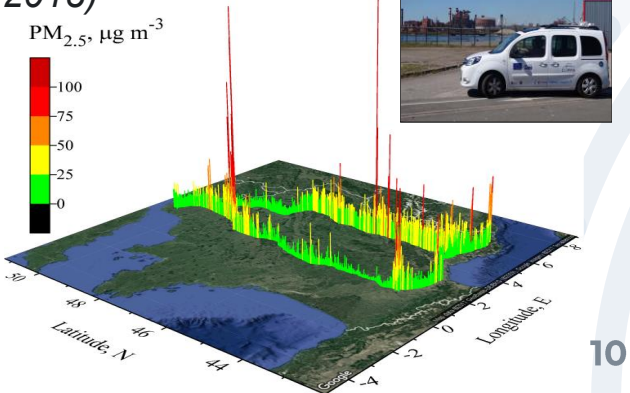
LiDAR | Sun photometer | In situ

Mobile measurements in France (2016-2018)



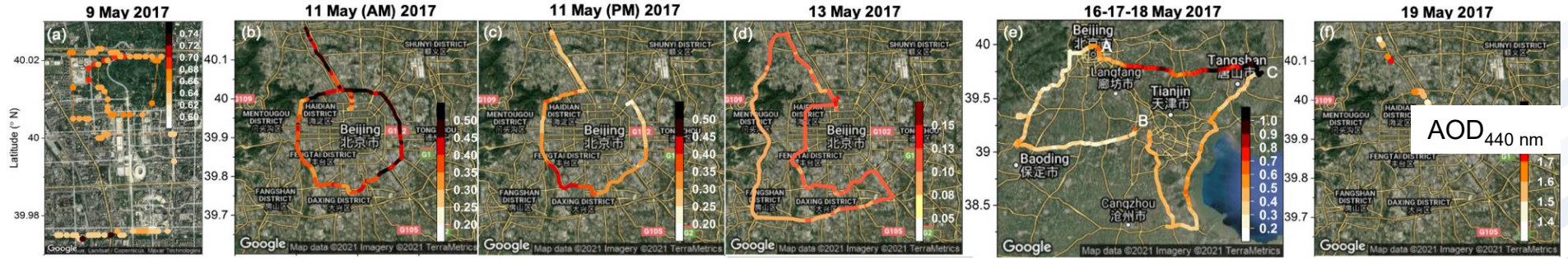


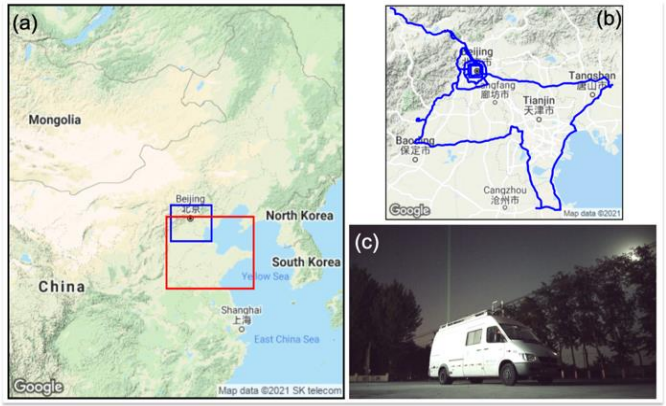
(Popovici, thesis, 2018)

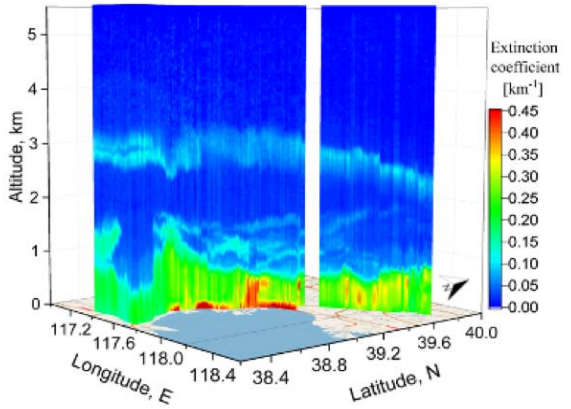


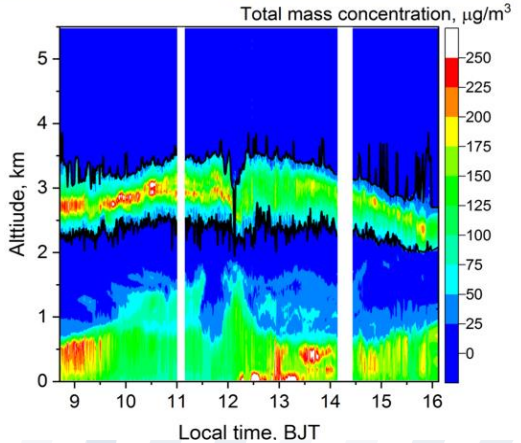
- On-road observations of aerosols spatial variability at fine scale (2 km resolution) – over 20 campaigns
- Fast response during pollution events in N. France
- First vertical and columnar mapping of aerosols properties at such large scale (1000 km)
- Identification of traffic jams, tunnel pollution, busy axis

Mobile measurements in China (MOABAI, 2017)









(Popovici et al., Atmosphere, 2022)

- Essential Climate Variables (ECV) on aerosols properties: AOD, layer height, extinction profiles
- Added values: spatial columnar volume size distribution (GRASP) and mass concentration profiles

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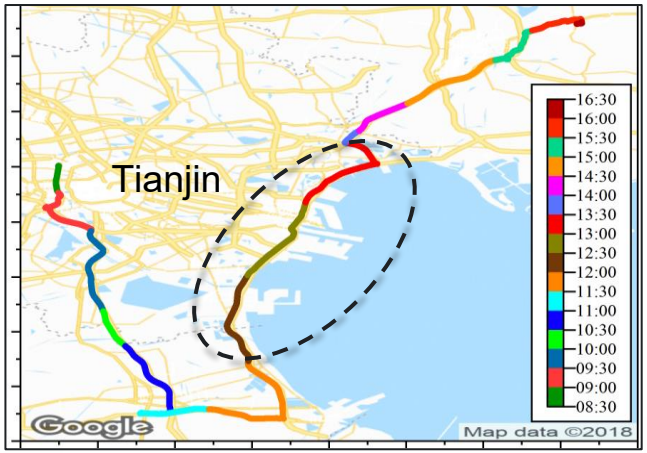
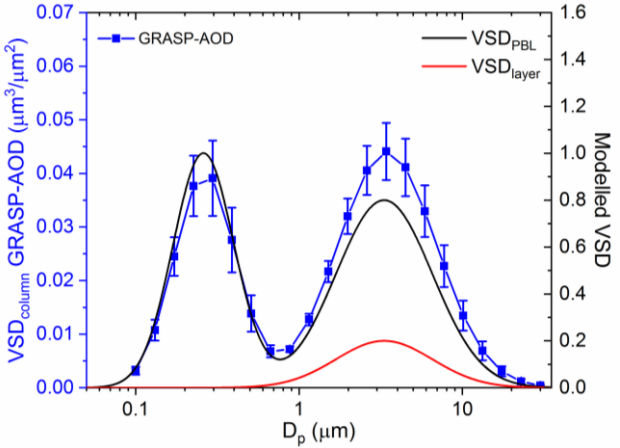
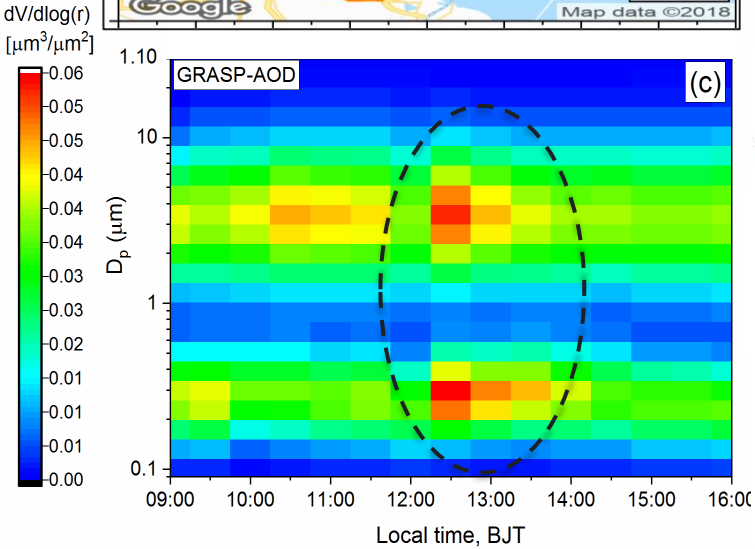
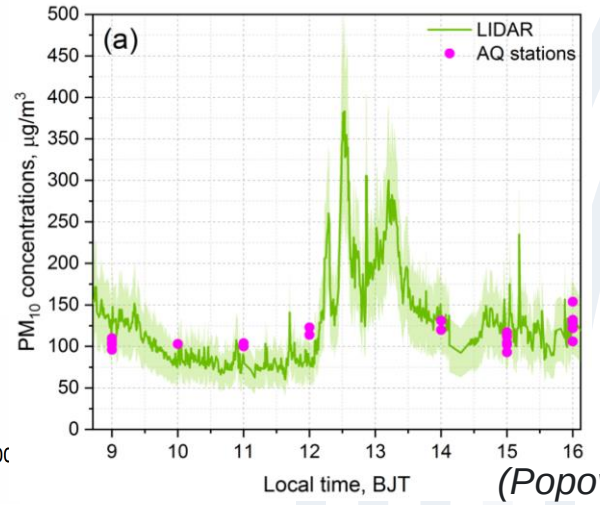
Mobile measurements in China (MOABAI, 2017)





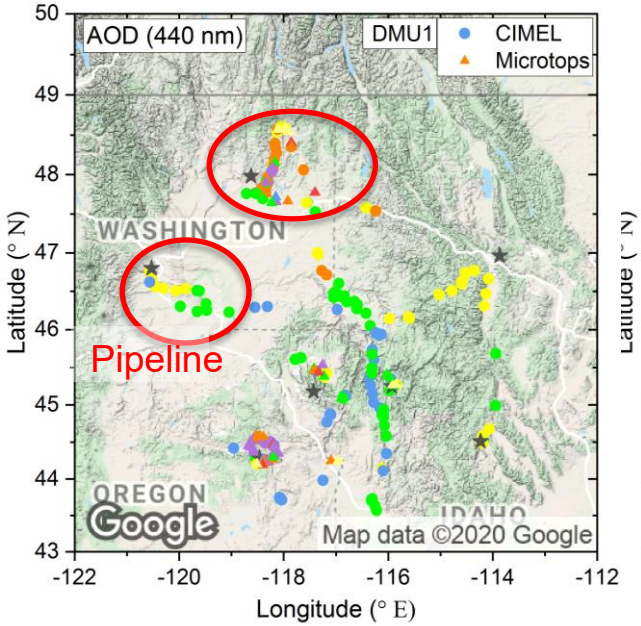


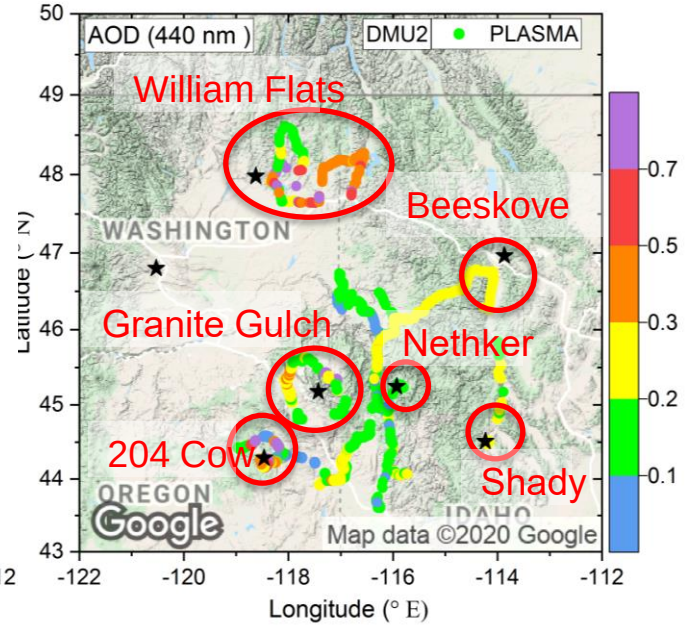


- Volume size distribution retrievals with GRASP from PLASMA AOD
- Separate columnar (photometer) and surface (in situ) aerosol contribution
- Use to refine calculations of mass concentration profiles

(Popovici et al., Atmosphere, 2022)

Mobile measurements in USA (FIREX-AQ, 2019)





- 2 cars (Dragon Mobile Unit)
  - **DMU1** (2 wl LIDAR, CE318-T)
  - **DMU2** (1 wl LIDAR, PLASMA)

- Mapping of AOD in mountainous region: 7 fires investigated close to the source
- First tests of CE318-T photometer on a car: difficulty for fast movements, improvements needed for future version
- Higher coverage with PLASMA photometer (fast measurements, 10s)

(Sanchez-Barrero et al., in prep.)

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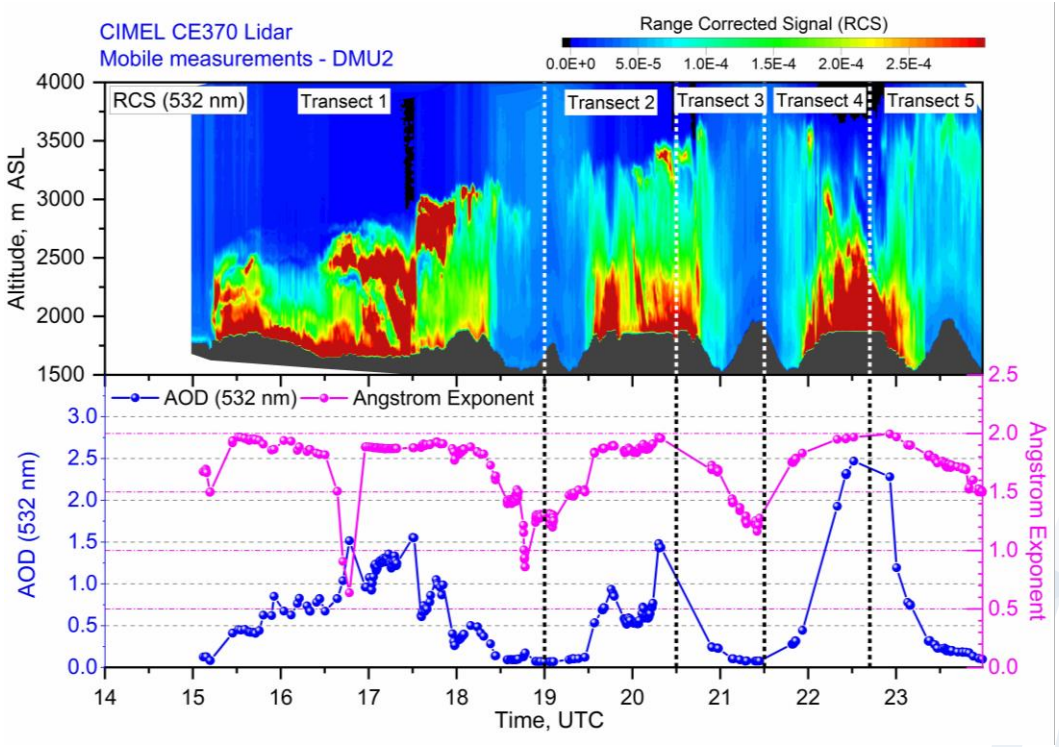
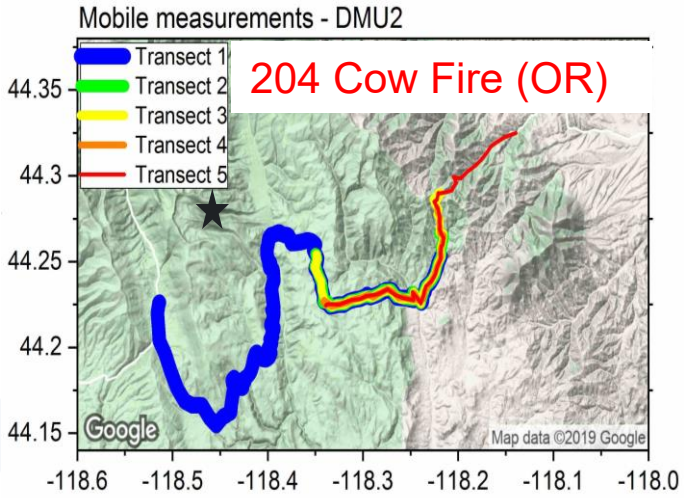
Mobile measurements in USA (FIREX-AQ, 2019)





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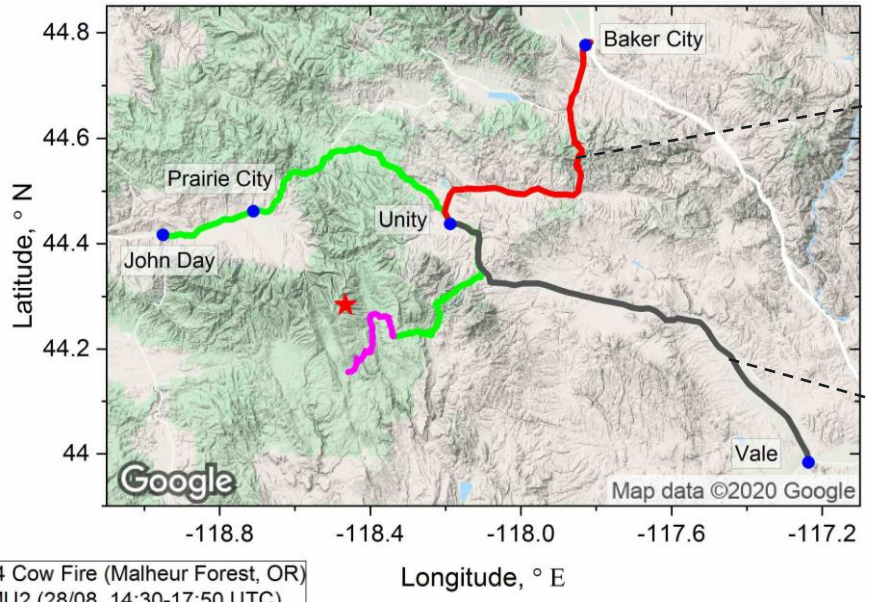
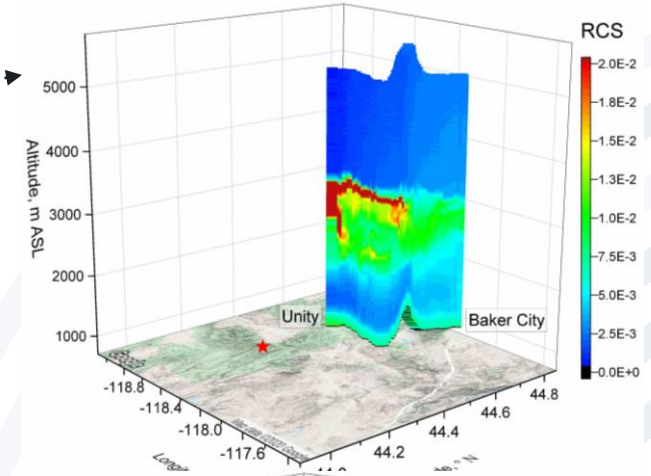
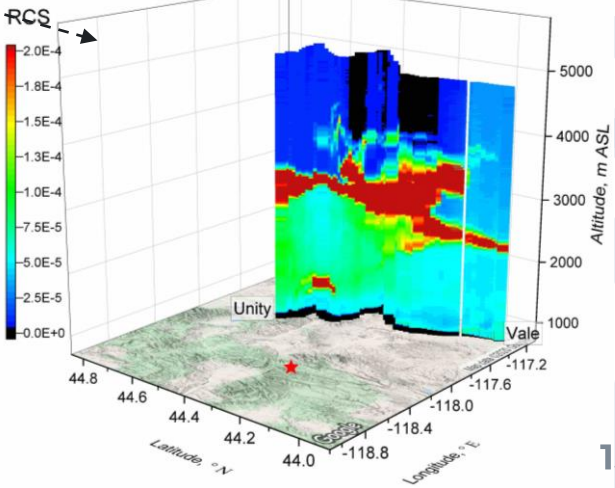
- AOD magnitude highly variable in the vicinity of the fire due to significant changes in aerosol loading
- Vehicles moving in and out of the smoke plume indicate that smoke subsided near the ground and nearby valleys

(Warneke et al., JGR, 2023)

Mobile measurements in USA (FIREX-AQ, 2019)







- 2 lidars on 2 cars allow to map the dispersion of smoke in different directions, NE and SE
- Real vertical and spatial distribution of smoke close to source, valuable for smoke dispersion models

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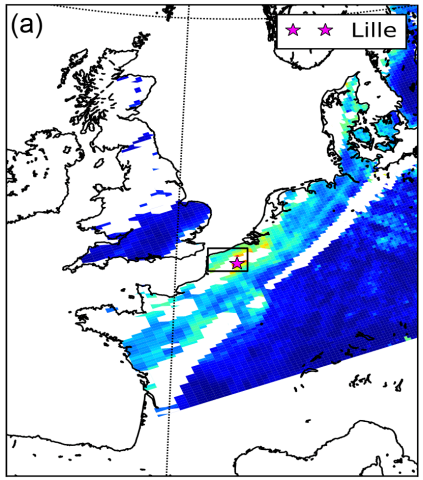
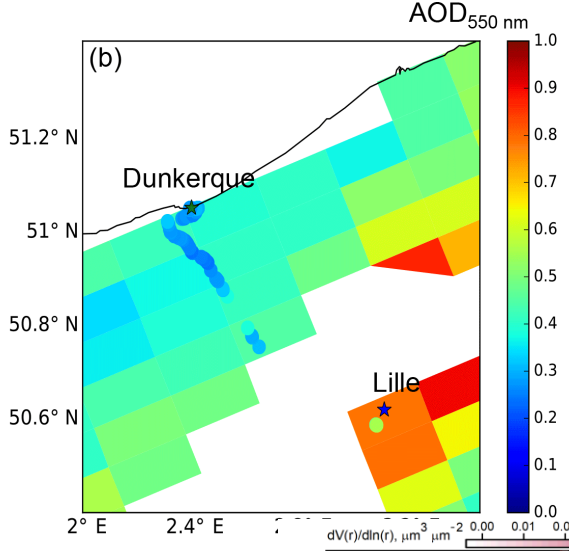
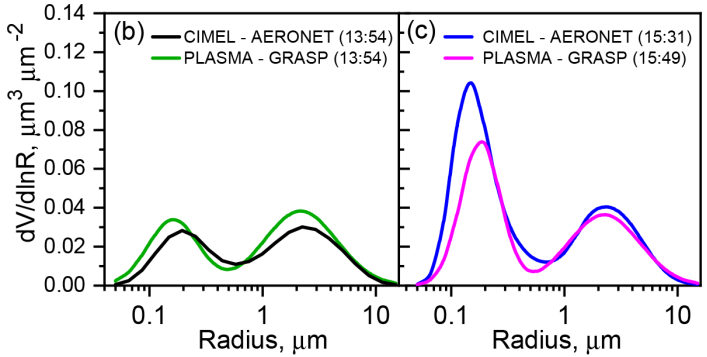
Applications: satellite CAL/VAL (MODIS)

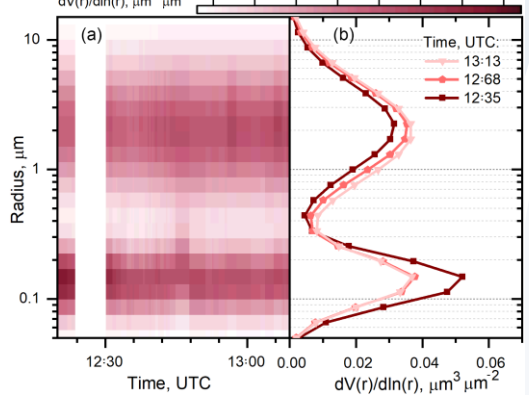


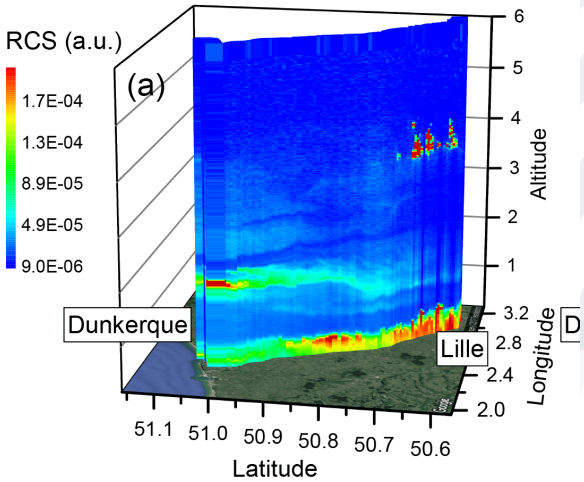


- Application of GRASP to mobile measurements of AOD
- Retrieval of columnar size distribution
- Comparison with satellite AOD

(Popovici et al., AMT, 2018)

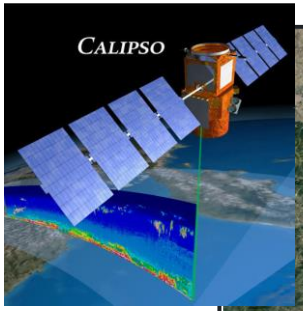






Applications: satellite CAL/VAL (CALIOP)

- Coordinated measurements
- Follow the satellite track
- Good agreement of extinction (AOD_{532} = 0.3-0.8)
- Good agreement of PBL top



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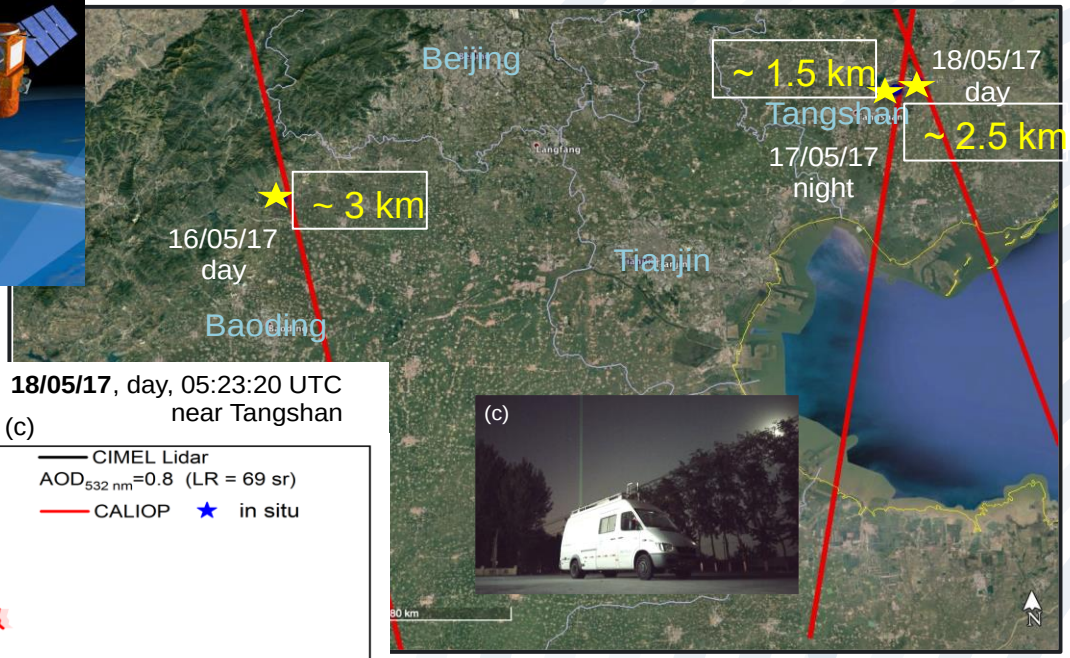

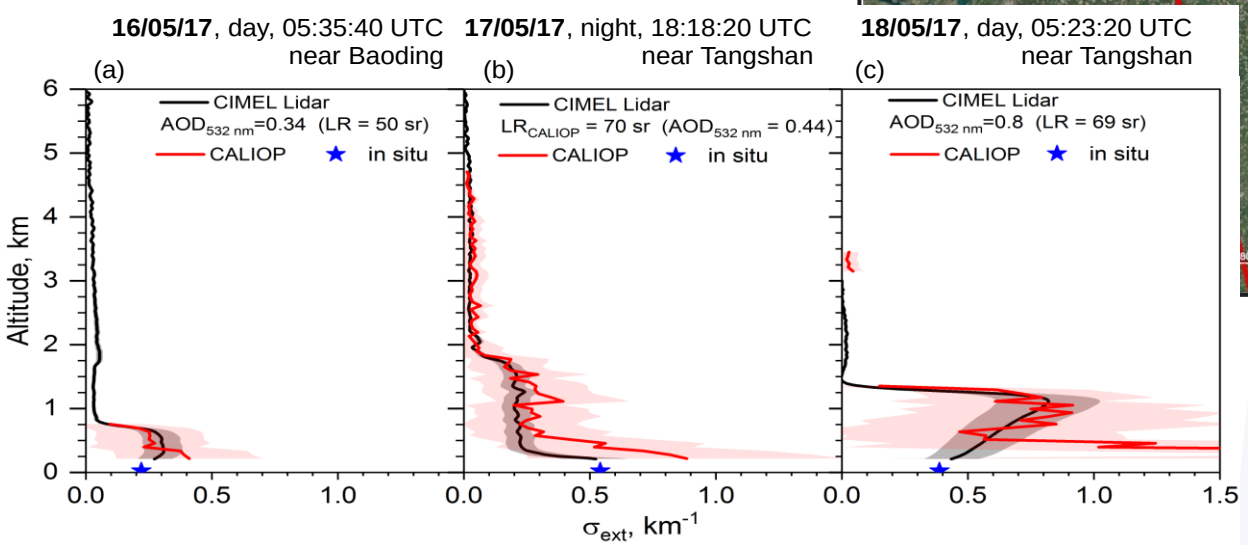

Perspectives

https://www.agora-lab.fr/

- **Ongoing developments on mobile photometer**:
  - continue on Advanced PLASMA (tests on car, aircraft, ship)
  - shipborne CE318-T: analyse radiances data from recent campaigns
- **Ongoing developments on mobile CE376 LIDAR**:
  - improve robustness to mechanical stress (vibrations, acceleration)
  - response to harsh environments (sea-spray, temperature variations and extremes)
- **Projects**
  - OBS4CLIM/ACTRIS-FR (2021-2028): 4 CE376 lidars (incl. 1 on train) (2024,…)
- **Campaigns**
  - Shipborne photometer on NOAA's RV (TBD)
  - Integration of CE318-T photometer on mobile platform, ESA/QA4EO (ship TBD)
  - Integration of CE376 lidar on Polar POD around Antarctica (2023, …)
  - Coordinated ground-based and aircraft measurements (AERO-HDF, France)

Thank you for your attention!

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