Metrology and Cal/Val campaigns for aerosols

WP 2240

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Laboratoire d'Optique Atmosphérique (U. Lille / CNRS)

Service National d'Observation / ACTRIS-France

1. **Business as usual activity (operational services + projects)**

2. Traceability to GAW/PFR at OHP : Day time AOD

3. Comparison NASA / CNRS (Day time AOD)

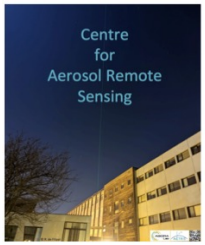
4. Campaigns / Intensive Observation

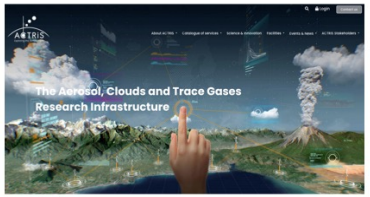
5. **Instrumental developments for innovative atmospheric measurements for Cal/Val**

6. Conclusion and planned actions for 2022-2025

7. Publications

1. Business as usual activity (operational services + projects)





Services :

- 85 /year calibration services provided by CNRS (50 / y in the frame of the ACTRIS infrastructure).
  - AOD calibration, since early 2019, at Observatoire de Haute Provence, supervised by LOA.
- QC/QA, Maintenance, etc
- Implementation of mobile observation (new service in progress)

Traceability:

- AOD traceability to NASA, since 2019 (CNRS reference photometers are calibrated at Mauna Loa calibration)
- Radiance traceability to NASA (travelling instrument)
- AOD traceability to PFR/GAW, since 2020 (at OHP)

Stations :

15 new stations into AERONET since end 2019.

Instruments :

Since end 2019, several stations operating a very old instrument upgraded their instrument
All stations have to operate a CE318**T** by end 2025
ESA also contributed to the upgrade of CNRS calibration platforms
Mobile photometer development

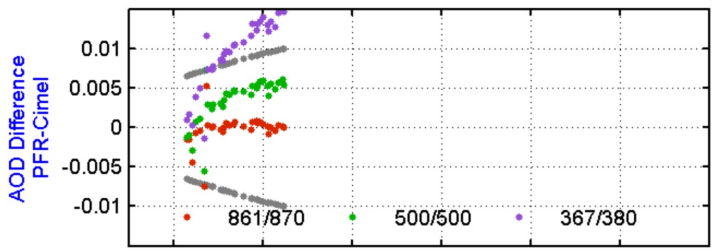
Staff : In 2021, 2 permanent positions obtained in CNRS (LOA and OHP) for QC/QA and calibration.

Event : AERONET in COP26 in October 2021 (https://www.actris.fr/aeronet-presente-a-la-cop26/).

Metrology : QA4EO/MAPP /H2020 (FOV measurements, new led-based calibration source, radiance traceability to SI)

2. Traceability to GAW/PFR at OHP : Day time AOD

- PFR removed by end of september 2021 for re-calibration



Comparison Results (points=31):
Differnces PFR - Cimel

862 nm: 0.07± 1.91 (x10^{-3})
___ 97% within WMO limits

500 nm: 4.24± 2.86 (x10^{-3})
___ 97% within WMO limits

Angstrom exp.
368-862nm & 440-870nm:
0.09± 0.04

- Re-calibrated PFR back to OHP in April 2022 (+ 6 months).

- Since end 09/2021, CNRS swaped out 4 reference photometers at OHP

- Activities and analysis to be continued in phase 2 and in the frame of ACTRIS-CH contribution

ACTRiS

AERONET-Europe Calibration Sensin
Automatic Sun/Sky/Lunar Photometer
(CARS-ASP-FR

Service National d'Observation
PHOTONS/AERONET-EARLINET
Laboratoire d'Optique Atmosphérique
CNRS-Université de Lille
Villeneuve d'Ascq, France

Calibration Certificate

(ACTRIS IMP Transnational Access to CARS-ASP-FR)

Photometer: # 912

Project leader : Peter Hrabčák
Aerological and radiation measurement Center
Slovak Hydrometeorological Institute
Poprad-Ganovce, Slovakia

I, Philippe Goloub, herewith confirm that in the context of ACTRIS Transnational Access the following instrument services were performed at the ***CNRS CARS Unit*** *of the European AERONET Calibration Service Centre:*

- ☒ Calibration/maintenance of field instrument
- ☐ Calibration of reference instrument
- ☒ Final functional test
- ☒ Calibration update in AERONET database
- ☒ Data reprocessing applied
- ☒ Data raised to QA level (AERONET level 2)

Project Acronym: AELOA_ SK_POP1-22

Calibration date : 04/01/2022

The calibration process of the instrument was carried out

☒ successfully after 1☒ 2☐ 3☐ calibration process (unit of access).

Standard AERONET ☒ Non AERONET user & CIMEL customer ☐ Other types of Instrument ☐

The next calibration/maintenance is recommended in about 12 months after the present calibration date.
The PI will have to submit a new TNA application form for that purpose, including an update of the publications.

Important notice to user:
- *Daytime AOD are traceable to GAW/PMOD/WRC (OHP Observatory) and AERONET (NASA/Mauna Loa)*
- *Radiance calibration is traceable with AERONET (NASA/GSFC)*

Comments to user:

The calibration procedure was provided free of charge

Villeneuve d'Ascq 20/01/22
Signature of access provider

(P. Goloub)

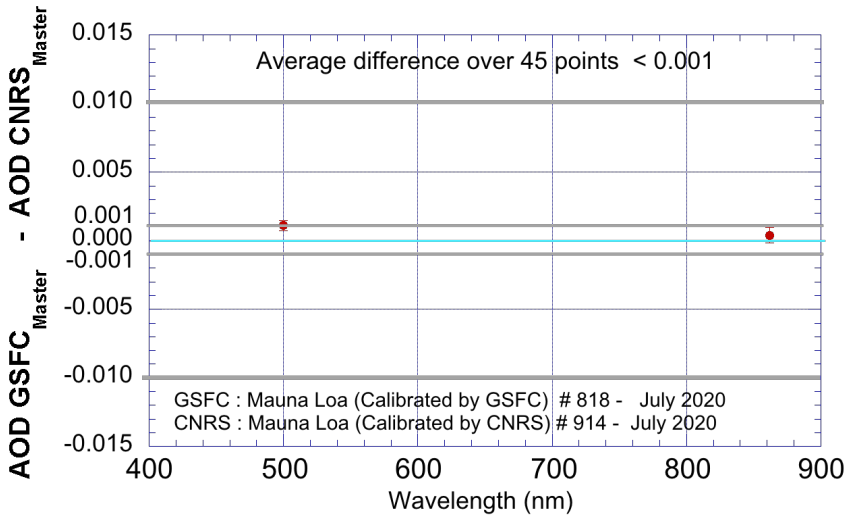
Reminder: *the following acknowledgement sentence is mandatory for all publications: Authors acknowledge AERONET-Europe for providing calibration service. AERONET-Europe is part of ACTRIS-IMP project that received funding from the European Union (H2020-INFRADEV-2018-2020) under Grant Agreement No 871115*

https://www-loa.univ-lille1.fr/photons
https://www.actris.eu/Home.aspx (v 22.04.2021)

Email : anne.priem@univ-lille.fr

3. Comparison NASA / CNRS (Day time AOD)

Mauna Loa : same location, same software, same date, different instrument and different 'calibrator'



2. July 2020 values : GSFC and CNRS < 0.001

3. October 2020 values : similar

4. Feb. 2021 (1143 vs 864) : 0.0006 (mean difference over all channels, 340-1640 nm)

3,9E-05	0,0012	0,0007	0,0001	-0,0002	-0,0015	0,0010	0,0006	(difference)
440	500	675	870	1020	380	340	1640	(channel)

5. etc …

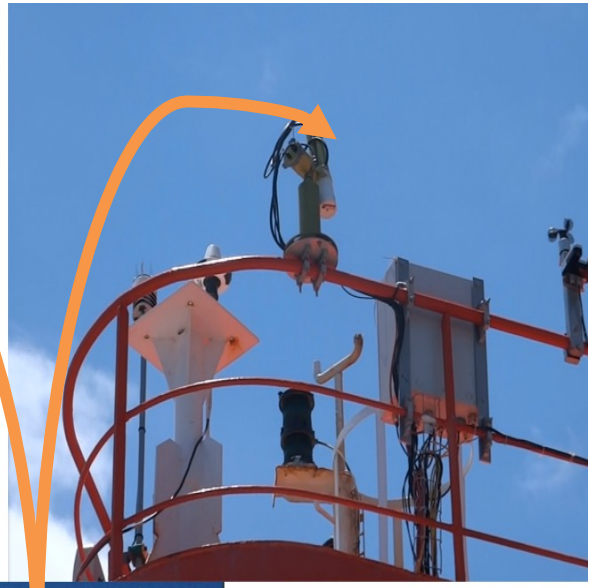
4. Campaigns / Intensive Observation

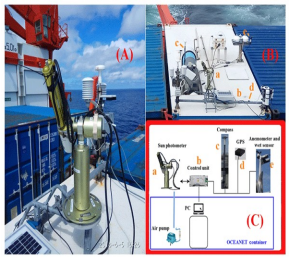
Shipborne photometer

Tracking
- Continuous track during measurements
- GPS

Sea spray
- Air flow in the collimator
- Dry and clean air
- With a standard collimator
- Pipe system

Data Processing
- Day and night AOD
- Almucantar





Marion Dufresne (MAP-IO)

01/2021

Campaigns and Data

2022 ….

2021

Marion-Dufresne campaign OP3-2021-11

Marion-Dufresne campaign MAYOBS-2021-09 (1 month)

Marion-Dufresne campaign OP2-2021-08 (1 month)

Marion-Dufresne campaign OASIS-BIO (8 days)

Marion-Dufresne campaign SCRATCH (1 month)

Marion-Dufresne campaign OP1-2021-03 (1 month)

Marion-Dufresne campaign Swing (2 months)

2020

Jeremy-Florent2 campaign near Boulogne-sur-mer (5 months)

Tangora campaign near New Zealand Sea2Cloud (20 jours)

2019-2020

PolarStern campaign Artic (Moon AOD) (1 year)

2019

Car campaign FIREX (2 months)

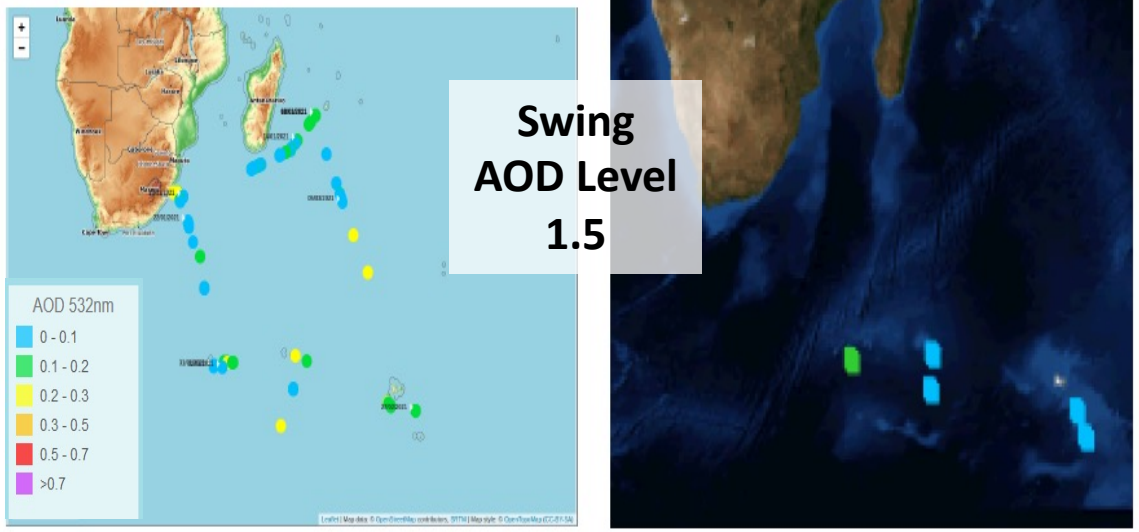
2018

PolarStern campaign Bremerhaven-Cap Town PS116 (2 months)

PolarStern campaign Punta Arenas-Bremerhaven PS113 (3 months)

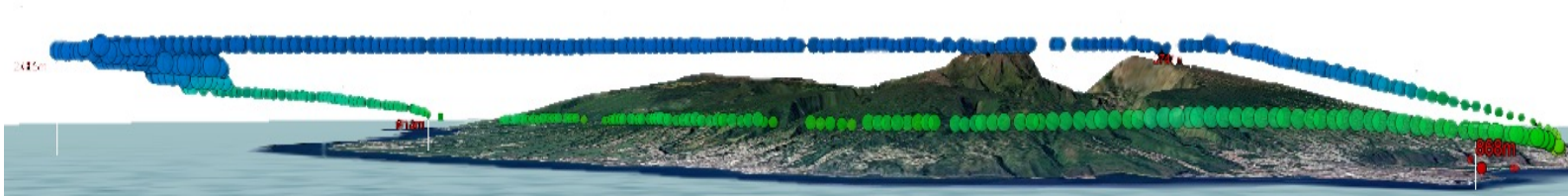
2017

Kommandor_Iona campaign Artic PS122 (2 months)



(a) AOD from CIMEL (b) AOD from Microtops

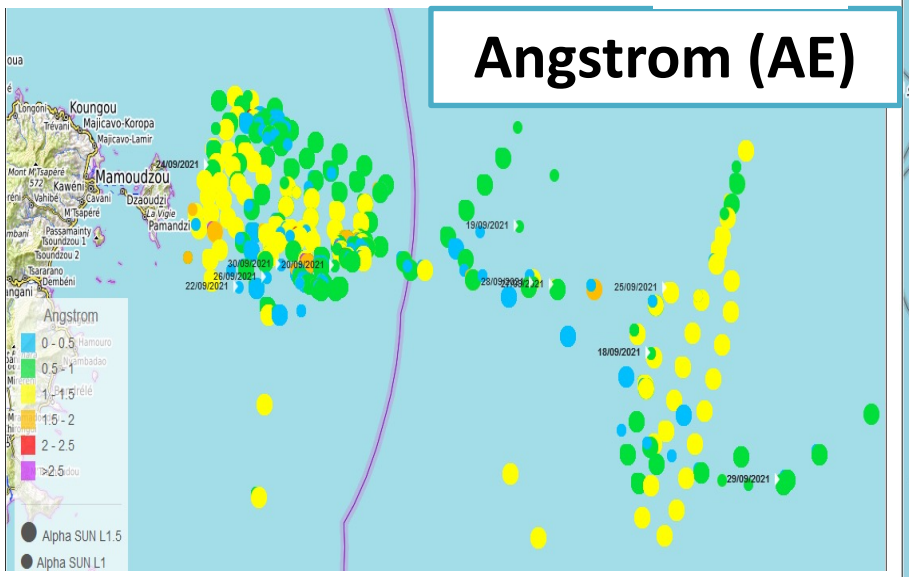
Map of the trajectory of the ship during the campaign from January 11 to Mars 09 2021.



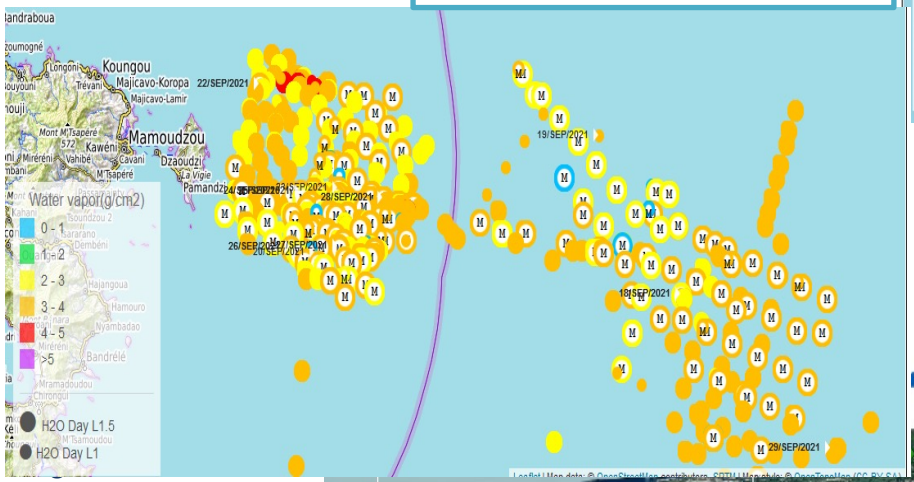
Around Madagascar

MAP-IO

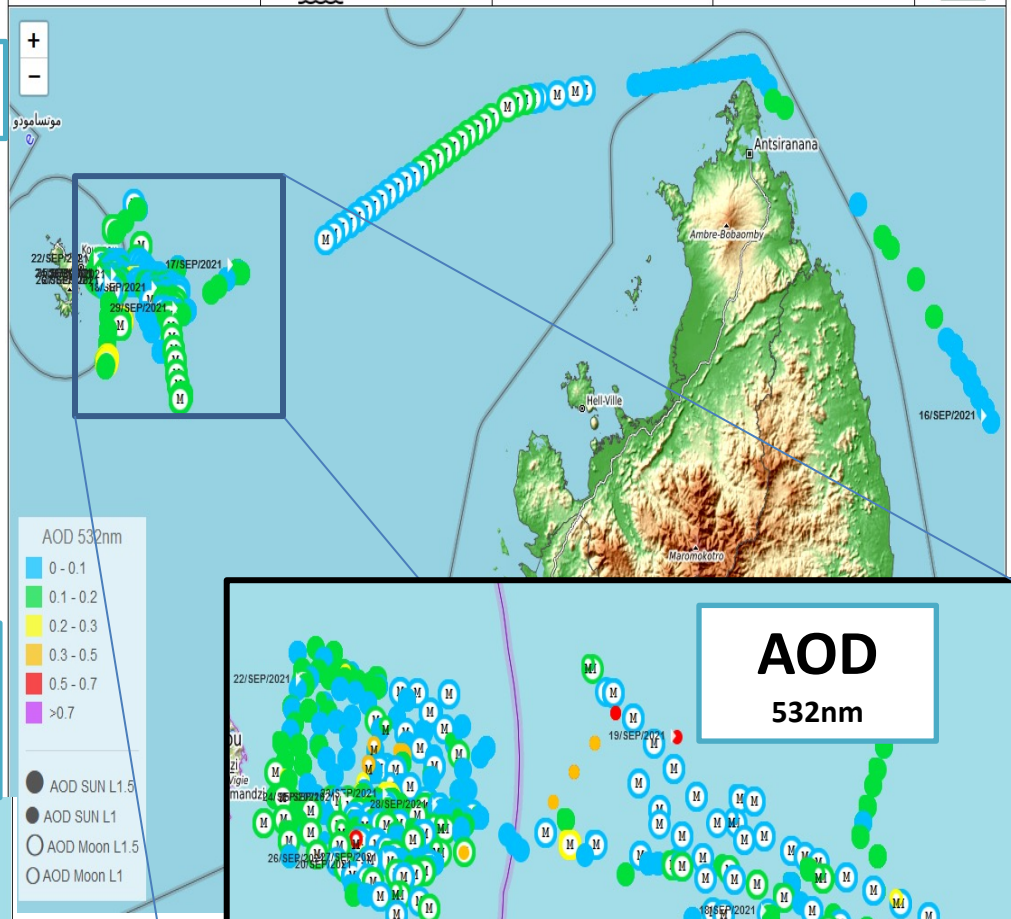
Angstrom (AE)



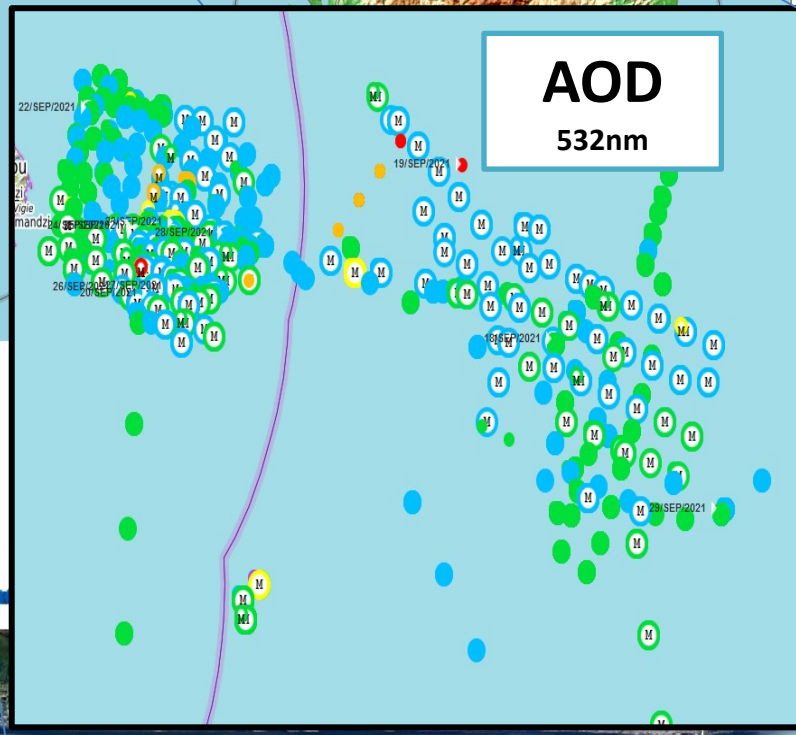
Water vapor (H2O)



Campaign MAYOBS #1273 between 2021-09-14 to 2021-10-03



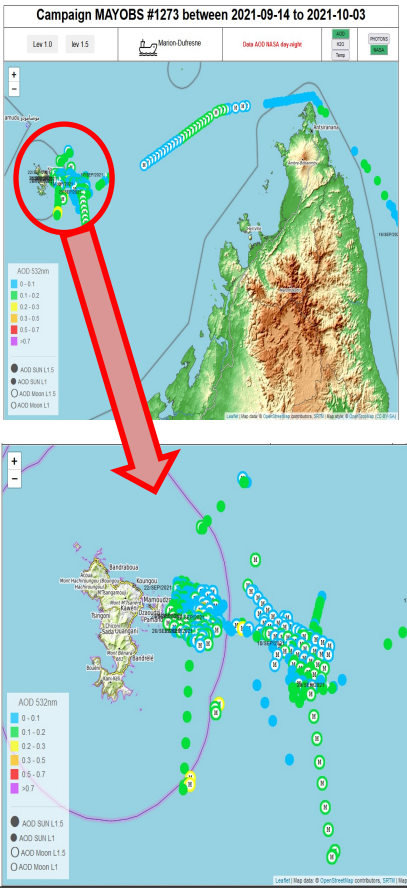
AOD 532nm

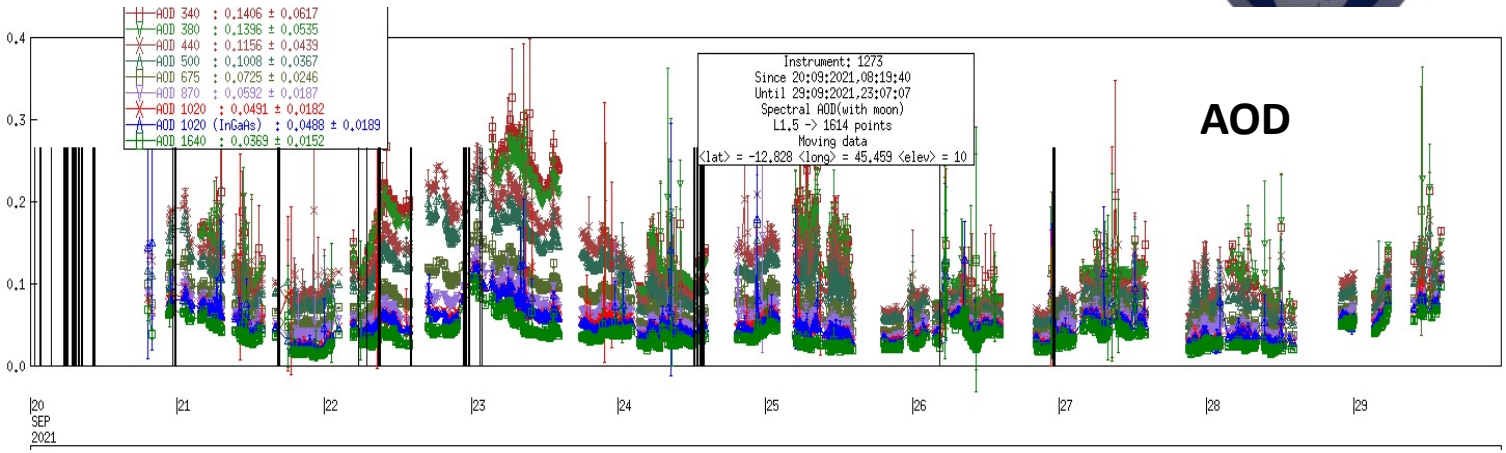


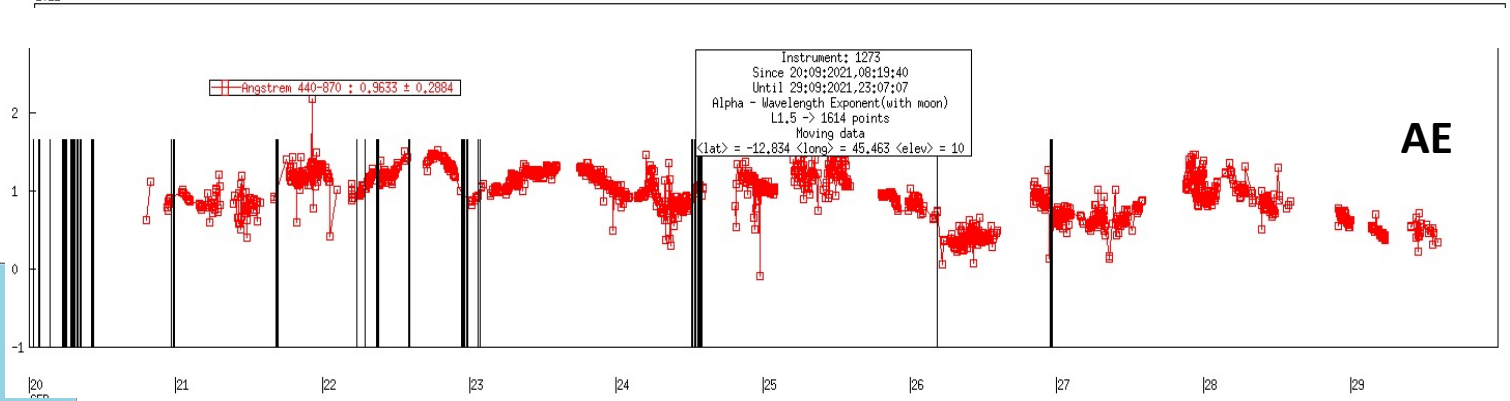
Time series (AOD, AE, H2O)

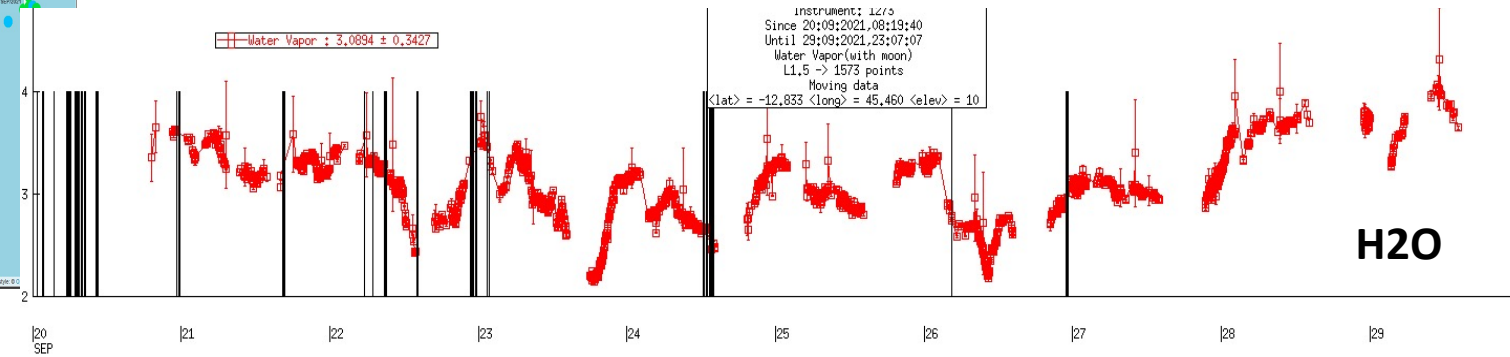
Day & Night

Around Madagascar

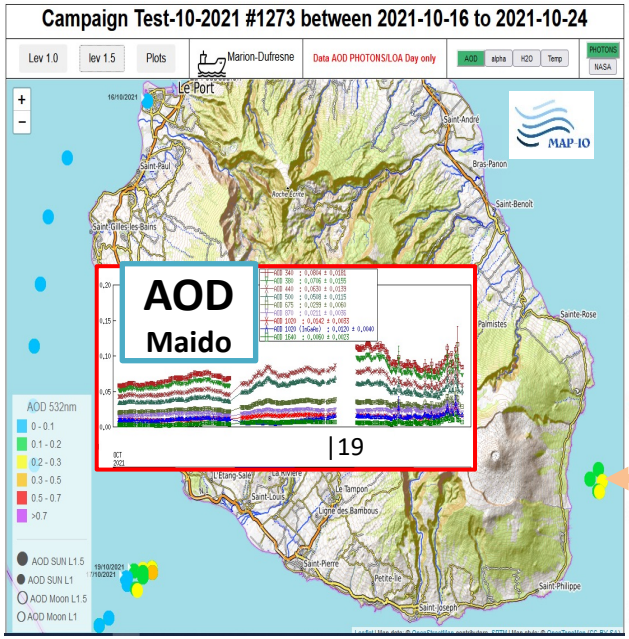


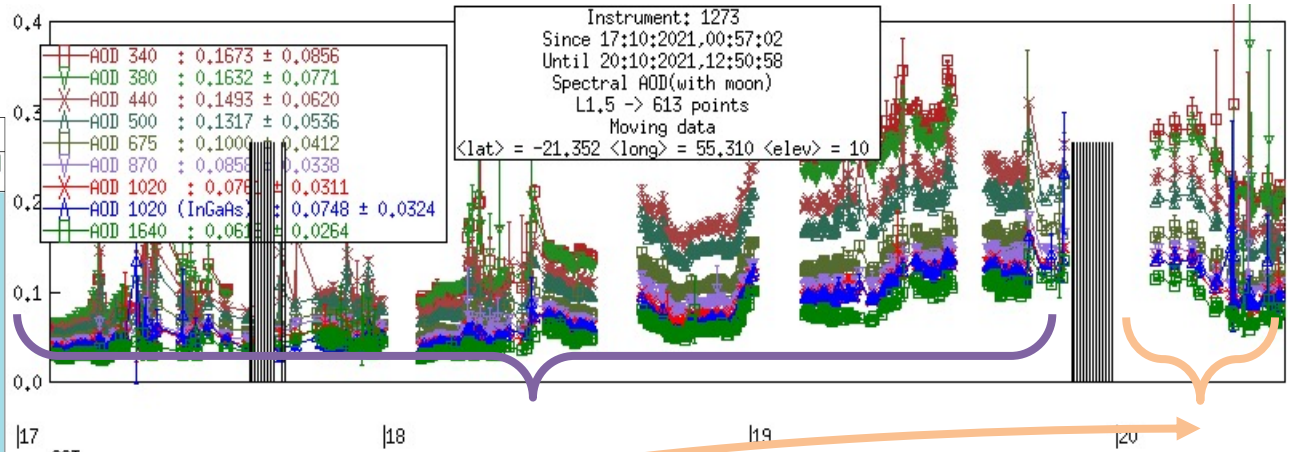


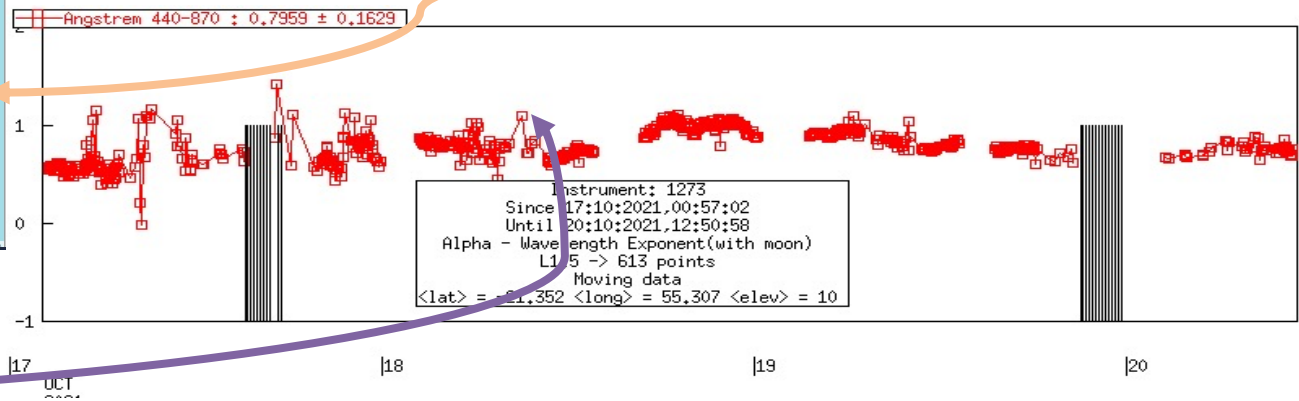


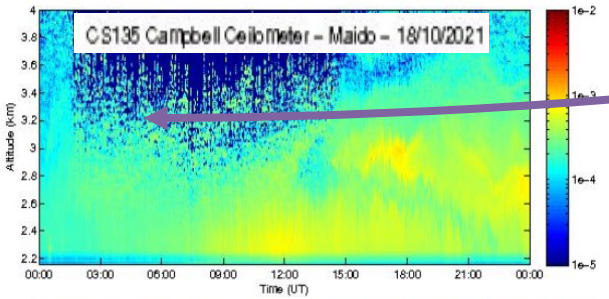


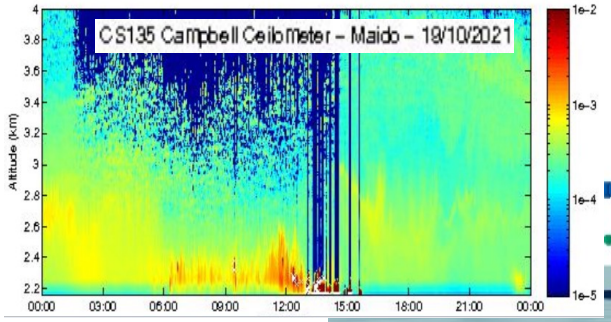
Reaching La Réunion
(Volcanic Plume)

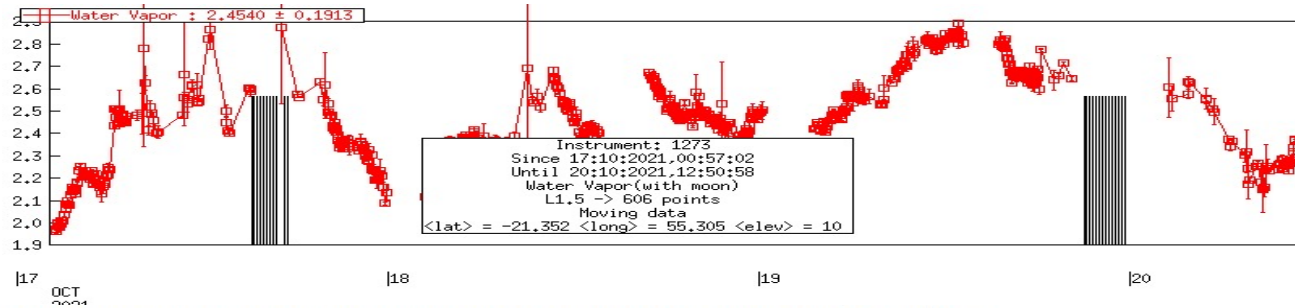


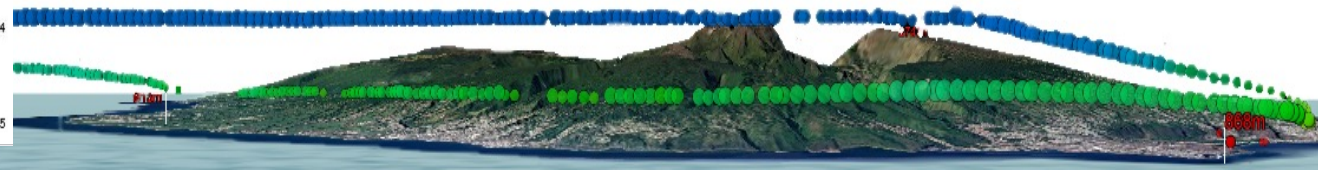












Shipborne CE318T-based photometer :

14 month of continuous automatic operation without major problem => concept validated.

- Setup a first short series on ship to create a new component to MAN
  => MAAN = Maritime Automated Aerosol Network

- Cover all oceans (new ships, new campaigns (i.e La Réunion -> Cayenne, april-July 2023, AMARYLLIS)

- ESA would support one mobile unit for CNRS in 2022 or 2023 (to be setup on research vessel, in regular operation)

- Some ACTRIS mobile exploratory platforms could integrate it.

- NASA/NOAA : one instrument setup in July/September 2022 (funded by NASA, *technical support CNRS*)

- Fundings for additionnal instruments to be found by partners. *Technical service supported by CNRS*

- Concentrate effort on the data processing (validity and inclusion of sky radiances for providing aerosol retrievals for maritime observation, from spectral AOD and spectral AOD+sky radiances).

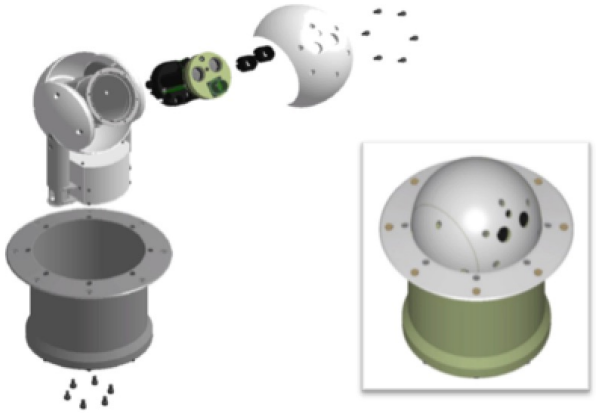
- **New services** : technical services (instrument monitoring and data)

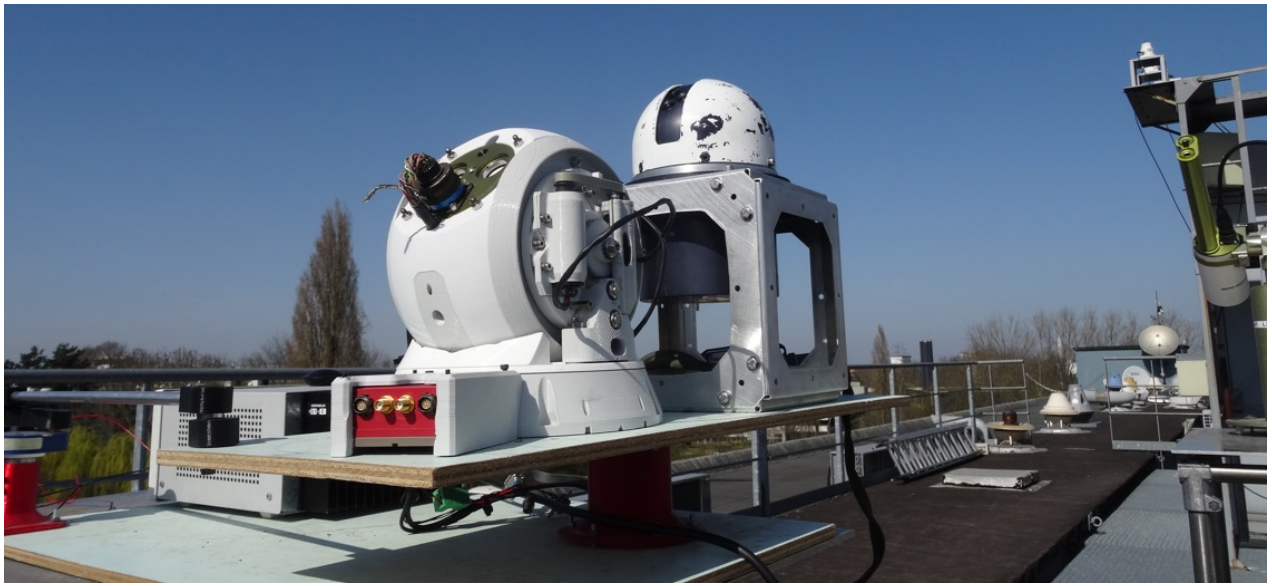
5.1 Advanced-Photometer Developpment (POC) - *AGORA-Lab (CNRS/CIMEL)*

Proof Of Concept Phase almost over (with a 3D printer version)

=> Airborne instrument (high speed, AOD, angular radiance, waterproof)

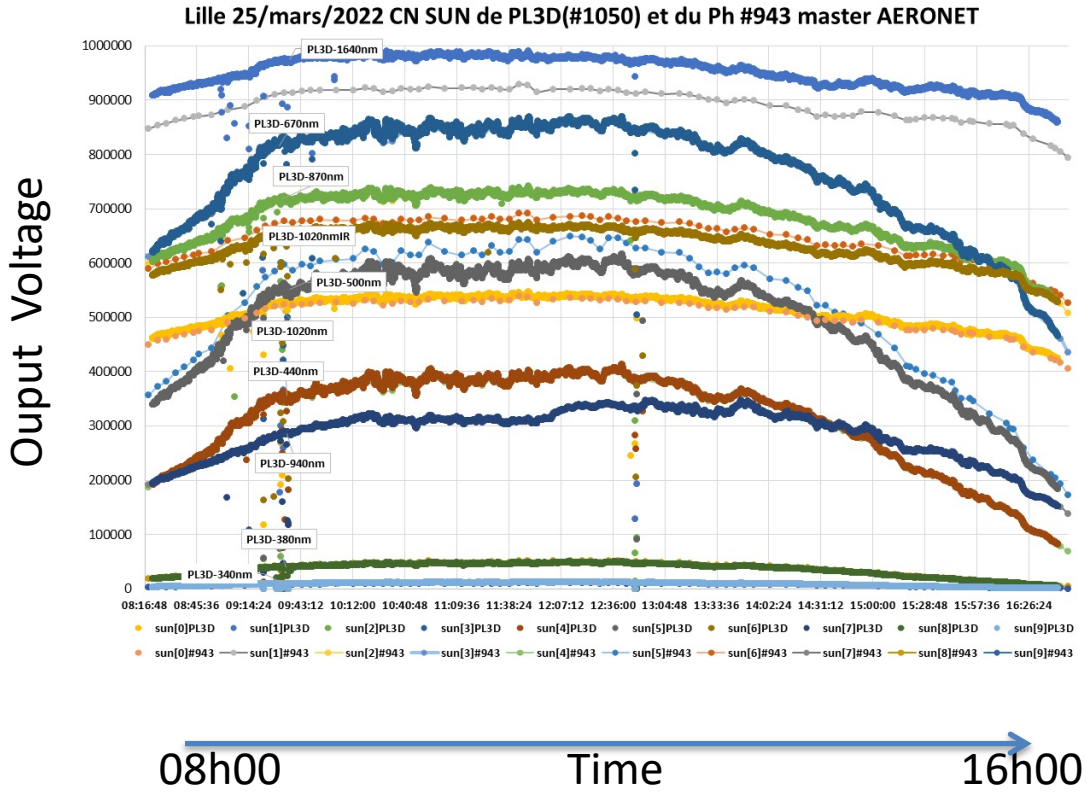
Test on a « oscillating platform »





Advanced-Photometer Developpment (POC)

- **Comparison in dynamic with fixed AERONET reference photometer => OK**
  (rotation : angular speed variable ~0.25 rad/s or greater)



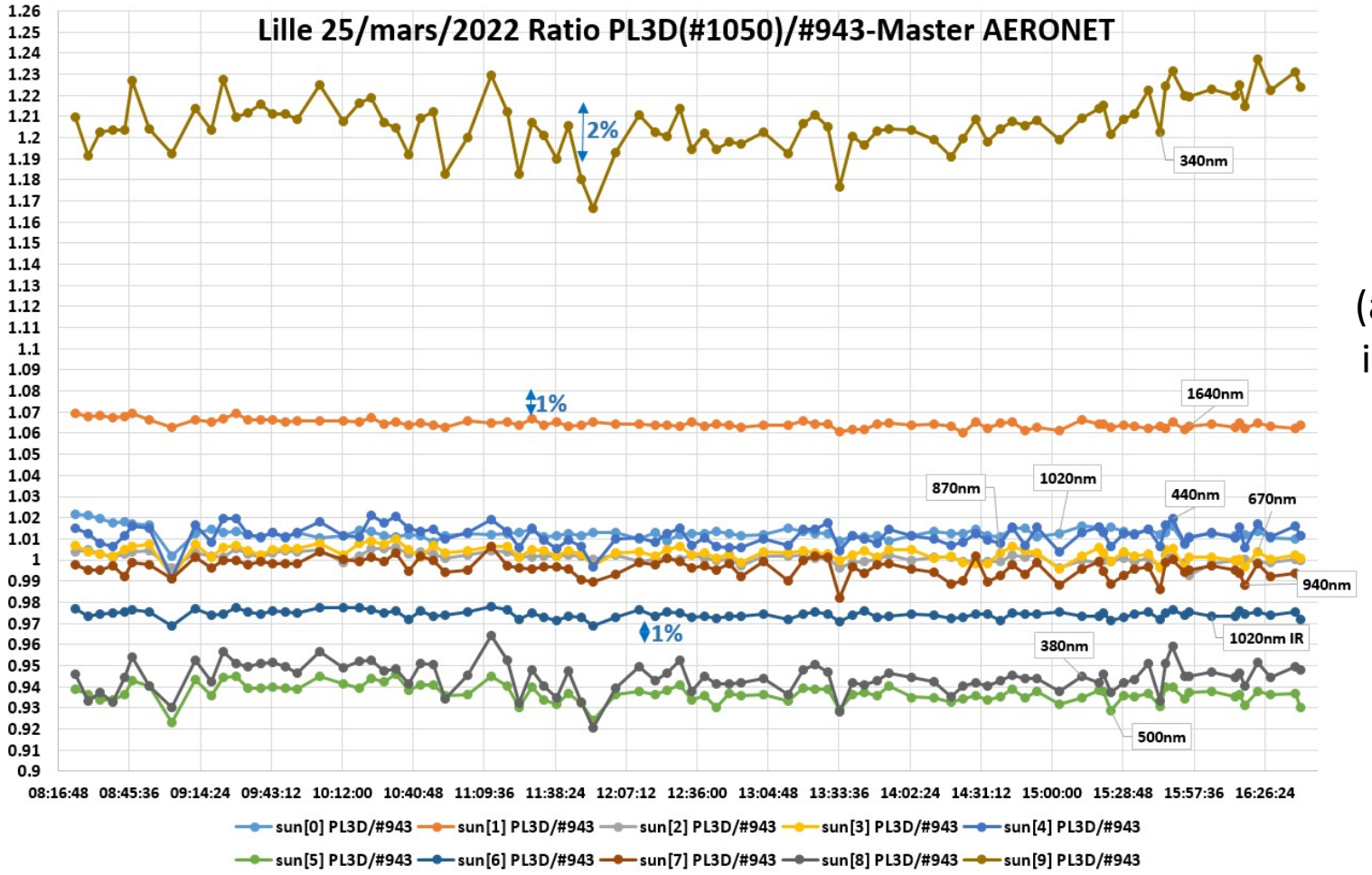
Advanced-Photometer + PLASMA
(mobile)
+
Reference CE318T (fixed)

- Prototype Advanced Photometer (#1050) frequency : 5 sec
- Reference CIMEL CE318T : 1,5 min (triplet) every 15 min.

Advanced-Photometer Developpment (POC)

- **Comparison in dynamic (motion) with fixed AERONET reference photometer => OK**
  (rotation : angular speed ~0.25 rad/s)

Ratio Signal A-Photometer / Signal CIMEL reference = very stable



AOD ~0.25
(a bit too high for inter-calibration)

Advanced-Photometer Developpment

- **Next steps**

in April/May 2022 :

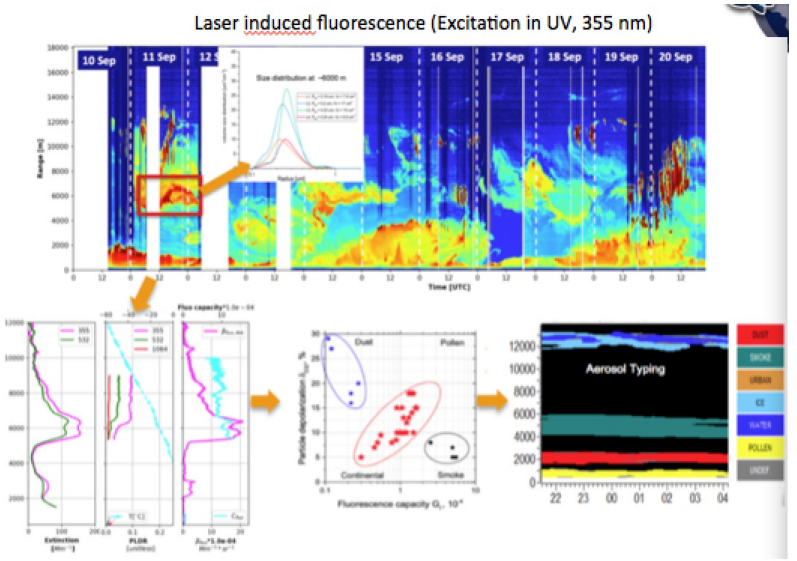
- check on MAMS (CNRS-LOA instrumented car)
- test moon tracking on the oscillating platform (oscillation simulator).
- test sun tracking without using high quality compass
- test Almucantar scenario « in motion » close to AERONET reference photometer

In 2022/2023 :

- design and build 1 pre-industrialized unit (new robotisation, 2022-2023)
- in 2025 on-board the new French airborne (ANVOLE)
- autonomous (without operator).
- be setup on any mobile platform

Instrumental developments for innovative atmospheric measurements for Cal/Val

- **5.2 New dev. on profiling atmospheric fluorescence measurements (2021-2028)**
  - OBS4CLIM national project (2021-2028).
  - 1 full time research-engineer (CNRS/Lille)
  - 1 Ph.D Student (2021-2024, W. Boissière)
  - *AGORA-Lab (CNRS/CIMEL)*

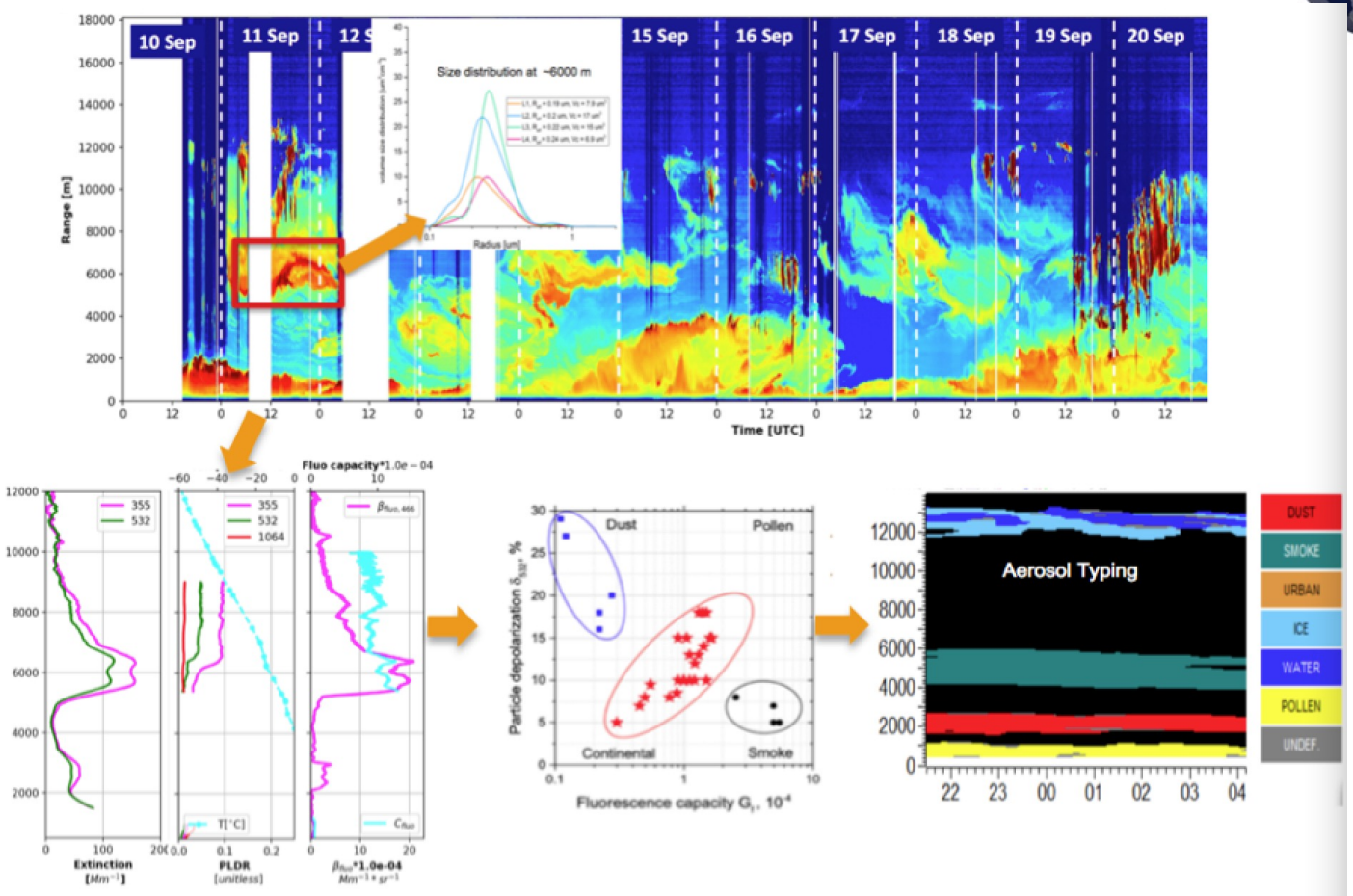


- **5.3 Automatic Compact Mobile Lidar measurements**
  - 1 Ph.D thesis (2021-2024, M. Barrero-Sanchez). *AGORA-Lab (CNRS/CIMEL)*
  - OBS4CLIM national project (2021-2028). First attempt on TGV
  - Polar-pod (fleet), around antarctica (2023-2025)
  - H2020/INFRA-TECH Call : ATMO-TECH project (technical consolidation to resist to hard conditions)

Instrumental developments for innovative atmospheric measurements for Cal/Val

What we gain with fluorescence ?

Laser induced fluorescence (Excitation in UV, 355 nm)



-> Depolarisation + fluorescence -> power tool for aerosol classification. We will add dimensions (spectral)

-> High power lidar (high quality of lidar signal in UV (Elastic, Raman, depolar) => good for Earth-Care Cal/Val

-> New Lidar (LIFE) to be start operation in ~2023 .

-> Framework for LIFE processing : AUSTRAL (AUtomated Server for the TReatment of Atmospheric Lidars)

6. Conclusion & perspectives (QA4EO Phase 2) for 2022-2025

Activity 1: Provision of general support to the sun/sky-moon photometer calibration/maintenance/operation/data processing/training:

- a) provision of QC/QA, calibration for both stationary (AERONET) and mobile photometers,
- b) design and implementation of a NRT processing chain for mobile automatic photometer (high frequency direct sun/moon AOD, downward sky radiance data and retrieved aerosol products, new service)
- c) purchase and integration of a new led-based integrating sphere into calibration facility (system proposed within the frame of a potential CCN)

Activity 2: Setup and operation of a second ship-photometer on a research or commercial vessel

Activity 3: Provide innovative regular dataset from Mie-Raman-fluorescence lidar for cal/val applications, collocated with AERONET at ATOLL platform.

- **Supplementary through CCNs (expected in 2023)**
- CCN1: purchase and integration of second automatic ship-borne photometer on a scientific or commercial vessel (priority 1) - searching for campaign opportunities (contributions to Cal/Val)
- CCN2: purchased of a new Led-based calibration source to improve the current AERONET calibration service (priority 2)

Last Marion Dufresne Data (Indian Ocean) : QC/QA Data are available for space mission validation

End 2019- Early 2022 scientific production related to field or specific campaigns involving photometer & Lidar

Publications

Publications (by people directly involved in the project, and supported by the project). ESA/IDEAS-QA4EO acknowleged in many .

Veselovskii, I., **Hu, Q., Goloub, P., Podvin**, T., Korenskiy, M., Derimian, Y., Legrand, M. & Castellanos, P. (2020). Variability in lidar-derived particle properties over West Africa due to changes in absorption: towards an understanding. Atmos. Chem. Phys., 20(11), 6563-6581. 10.5194/acp-20-6563-2020

Hu, Q., Wang, H.**, Goloub, P**., Li, Z., Veselovskii, **I., Podvin**, T., Li, K. & Korenskiy, M. (2020). The characterization of Taklamakan dust properties using a multiwavelength Raman polarization lidar in Kashi, China. Atmos. Chem. Phys., 20(22), 13817-13834. 10.5194/acp-20-13817-2020

Veselovskii, I.**, Hu, Q., Goloub, P., Podvin**, T., Korenskiy, M., Pujol, O., Dubovik, O., and Lopatin, A.: Combined use of Mie-Raman and fluorescence lidar observations for improving aerosol characterization: feasibility experiment, Atmos. Meas. Tech.., https://doi.org/10.5194/amt-2020-291, 2020

Veselovskii, I.**, Hu, Q., Goloub, P., Podvin**, T., Choël, M., Visez, N., and Korenskiy, M.: Mie–Raman–fluorescence lidar observations of aerosols during pollen season in the north of France, Atmos. Meas. *Tech., 14, 4773–4786, https://doi.org/10.5194/amt-14-4773-2021, 2021.*

Torres, B. and Fuertes, D.: Characterization of aerosol size properties from measurements of spectral optical depth: a global validation of the GRASP-AOD code using long-term AERONET data, Atmos. Meas. Tech., 14, 4471–4506, https://doi.org/10.5194/amt-14-4471-2021, 2021.

Popovici, I.E.; Deng, Z.; **Goloub**, P.; Xia, X.; Chen, H.**; Blarel, L**.; Podvin, T.; Hao, Y.; Chen, H.**; Torres, B**.; et al. Mobile On-Road Measurements of Aerosol Optical Properties during MOABAI Campaign in the North China Plain. *Atmosphere* 2022, *13*,21. https:// doi.org/10.3390/atmos13010021

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