Upgrade of the AERONET Europe Calibration Facility for sun and moon photometer

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ESA/IDEAS Project / WP 3440-1

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« Aerosols Radiations Interactions » Group
Service National d'Observation PHOTONS/AERONET

Laboratoire d'Optique Atmosphérique
Université de Lille - CNRS

Frascati 5-6 July 2016

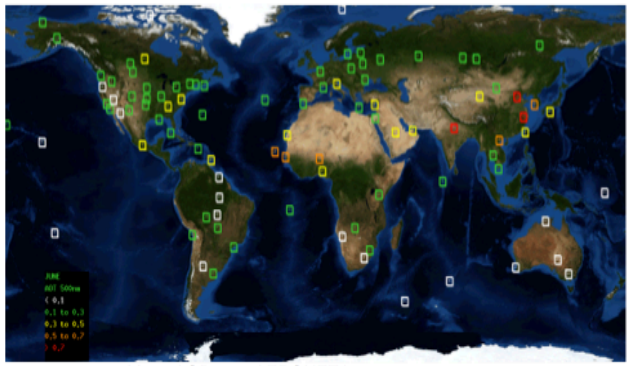
Scientific Objectives

- Scientists need high quality information on aerosols (space, ground, in between)
- Ground-based observations are organized in networks (permanent, temp. site, mobile)
- Space agencies and scientists need to calibrate, evaluate and validate sensors in orbit and aerosols products derived from these radiometric data.
- AERONET is a well establish global network for aerosol and water vapour

Beginning of 2016, the network has 300 observation sites.

OBJECTIVES

- Global aerosol characterization
- Satellite validation
- Synergism with other databases and instruments
- Validation of Aerosol models
- Aerosol early warning


Mean AOD over AERONET locations

France, Spain and EC support the national facilities components of AERONET and AERONET-Europe Calibration Center through **ACTRIS** 1/ 2 FP7/H2020 projects.

WP Objectives

- Upgrade European AERONET calibration facility and capacity ->
  Modern Ground-based technologies (instrument, calibration system)

ACTRiS

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http://www.actris.eu

ACTRIS

ACTRIS is the European **Research Infrastructure** for the observation of **Aerosol, Clouds, and Trace gases.** ACTRIS is composed of observing stations, exploratory platforms, instruments calibration centres, and a data centre. ACTRIS serves a vast community working on models and forecast systems by offering high quality data for atmospheric gases, clouds, and trace gases.

Projects:

➔ ACTRIS on ESFRI roadmap

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AERONET-Europe Calibration Centre

Data & Services -> AERONET-Europe

AERONET-Europe provides free calibration and standard maintenance services for CIMEL sun/lunar photometers involved in AERONET Network. Calibration is also offered to other types of sun/lunar-photometer. Calibration procedures are following the standard AERONET protocols and tools. Therefore, calibration uncertainties for AERONET Europe and AERONET GSFC are equivalent.

AERONET-Europe is led by LOA/CNRS and distributed between 3 calibration infrastructures in France (**CNRS/Meteo France**) and Spain (**UVa/AEMET**). All users can request a calibration through a permanent call.

READ MORE | APPLY | USER LOGIN | NEWS

Contact: Anne Priem (anne.priem@univ-lille1.fr). **Leader:** Philippe Goloub.

European Staff

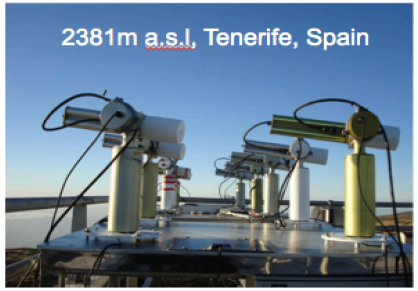
About 120 sites managed by the European facility in AERONET

AERONET Europe Calibration Facility

Towards a world-class facility

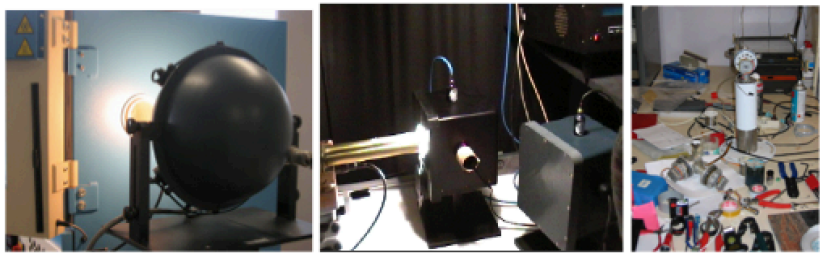
Inter-calibration platforms

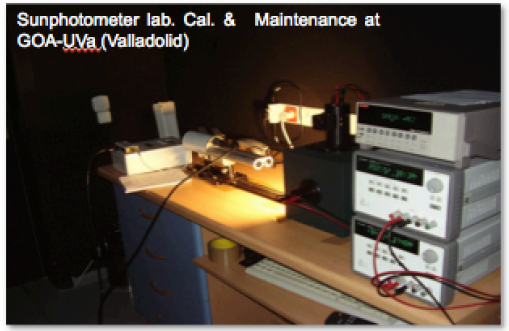
Master instrument platform

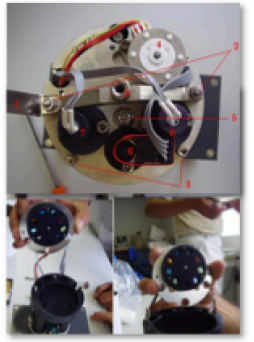


Radiance calibration labs

Sunphotometer lab. Cal. & Maintenance at LOA (Lille)







To serve the community, necessary upgrades of calibration facilities and units
(référence instrument = master instrument)

Upgrade of Calibration units (sun/moon)

Instrumentation : Sun Sky Lunar Multiband Photometer

Optical sensor head

- Includes two detectors in order to cover the entire spectrum from 340 nm to 1640 nm
- 1 Optical channel for each detector
- Narrow and precisely defined field of view (1.3°) for measurements of aureole very near from the sun
- High precision single-band filters inserted in the optical paths
- Motor-driven filter wheel for nine (possible up to twelve) single band filters
- Second motor-driven filter wheel adds polarization filters (in three directions) for models with polarization
- Silicon photodiode detector for the UV and visible spectrum, and InGaAs detector for IR.
- Extremely sensitive, low-noise electronic conversion, operating in a large temperature range
- A dual external collimator mounted on the head eliminates all stray lights

High precision robot

- Two high-resolution

Ac

Better

- T
- La

menus in all lightning conditions

- Built-in GPS for automatic data localization and time synchronization

All control, data acquisition, storage and communication functions are integrated within a single metallic and hermetic control box, of high robustness.

CIMEL Sun/Moon Photometer

Automatic sun/moon and sky photometer

Cimel Sun photometers most recent version (CE318-T) include:

- A new sensor head with an improved pointing device for tracking both sun and moon.
- A New control unit with improved
- A New robot (e.g., microstepping for faster and smoother robot response),
- Onboard data storage,
- Lunar measurement scenarios,
- GPS,
- A communication via serial, USB, cellular, and DCP)

Characterization and Evaluation of CE318T (5 units)

- **Temperature sensitivity** (LOA at Lille), mainly in 1020 nm- characterized and corrected.

- **Stability** (LOA, at Carpentras) departure from master instrument < 1%

- **Direct-Sun Calibration ($V_{o,sun}$):**
  Sun Langley technique (LOA, at Izana), for Master
  Sun inter-calibration (LOA, Carpentras; GOA, Valladolid), for Field

- **Direct-Moon Calibration (C_{moon}):**
  Moon Langley technique (AEMET, at Izana), for Master

  Moon inter-calibration (3 possibilities, *final protocol under definition*) :

  . Coïncident Night Measurements (with moon) : transfer from master
  . Coïndicent Day measurements ("Ratio Sun=Ratio Moon") = tranfer to Moon $V_{o,moon}$
  . No measurements needed, direct computation of C_{moon} from $V_{o,sun}$ and E_o (sun irr.)
  (thanks to very precise and stable electronics design, validated in Lab.)

$$\tau = \begin{cases} 1/m \cdot \ln(V_{0,\mathrm{sun}} / V_{sun}) & \text{Sun} \\ 1/m \cdot (\ln(E_{0,t,\mathrm{moon}} / V_{t,moon}) + \ln(C_{\mathrm{moon}})) & \text{Moon} \end{cases}$$

Barreto et al., 2015 (Izana, 2470m)
Li et al., 2016, subm, (in Tibet, 5000m)

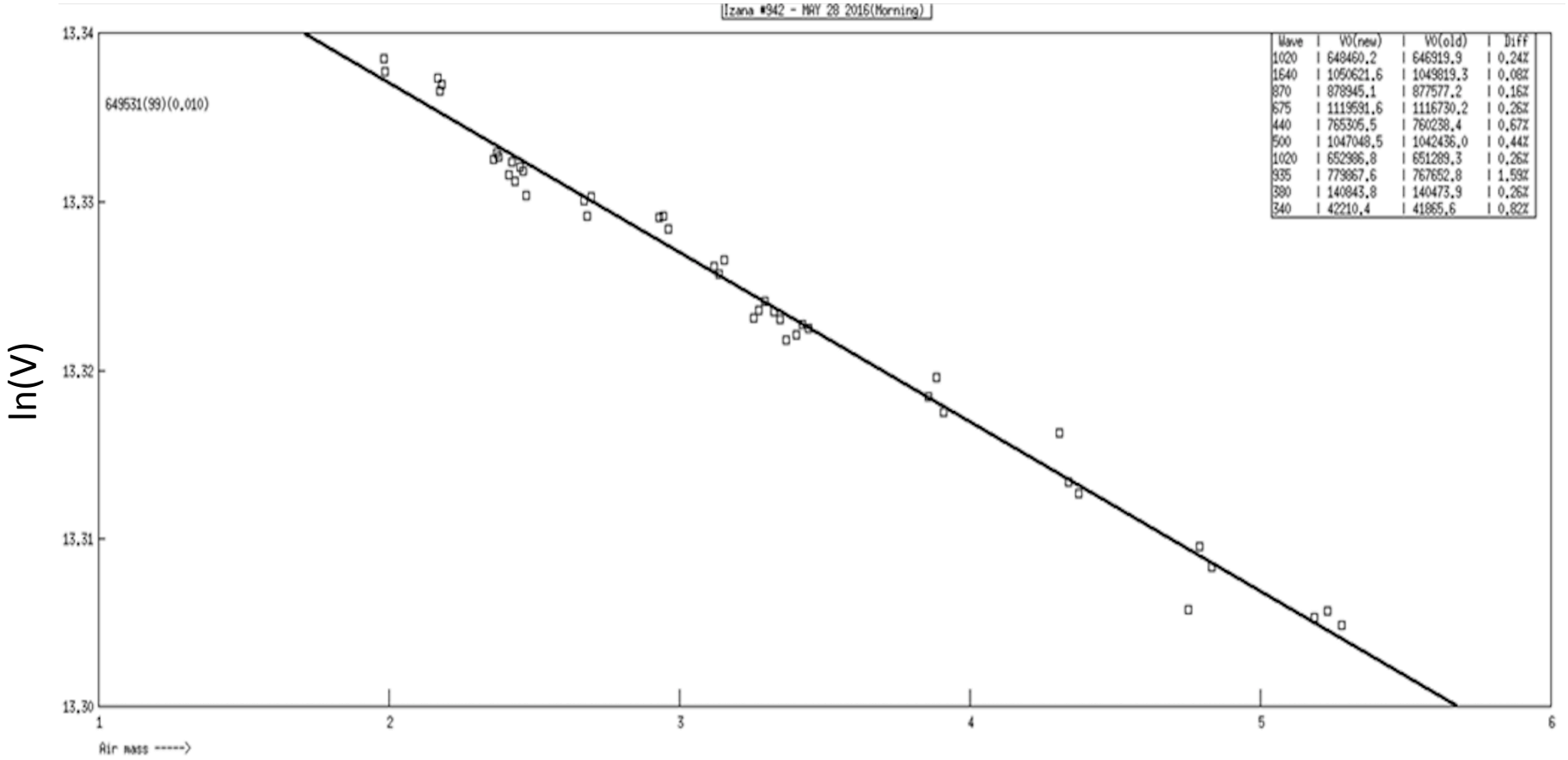
5 x (Control Unit + Sensor Head) CE318T have been purchased thanks to IDEAS

3 / 5 have successfully gone through all characterization and calibration steps
2 / 5 are still in the process

Examples of results will be shown

Langley Calibration (example)

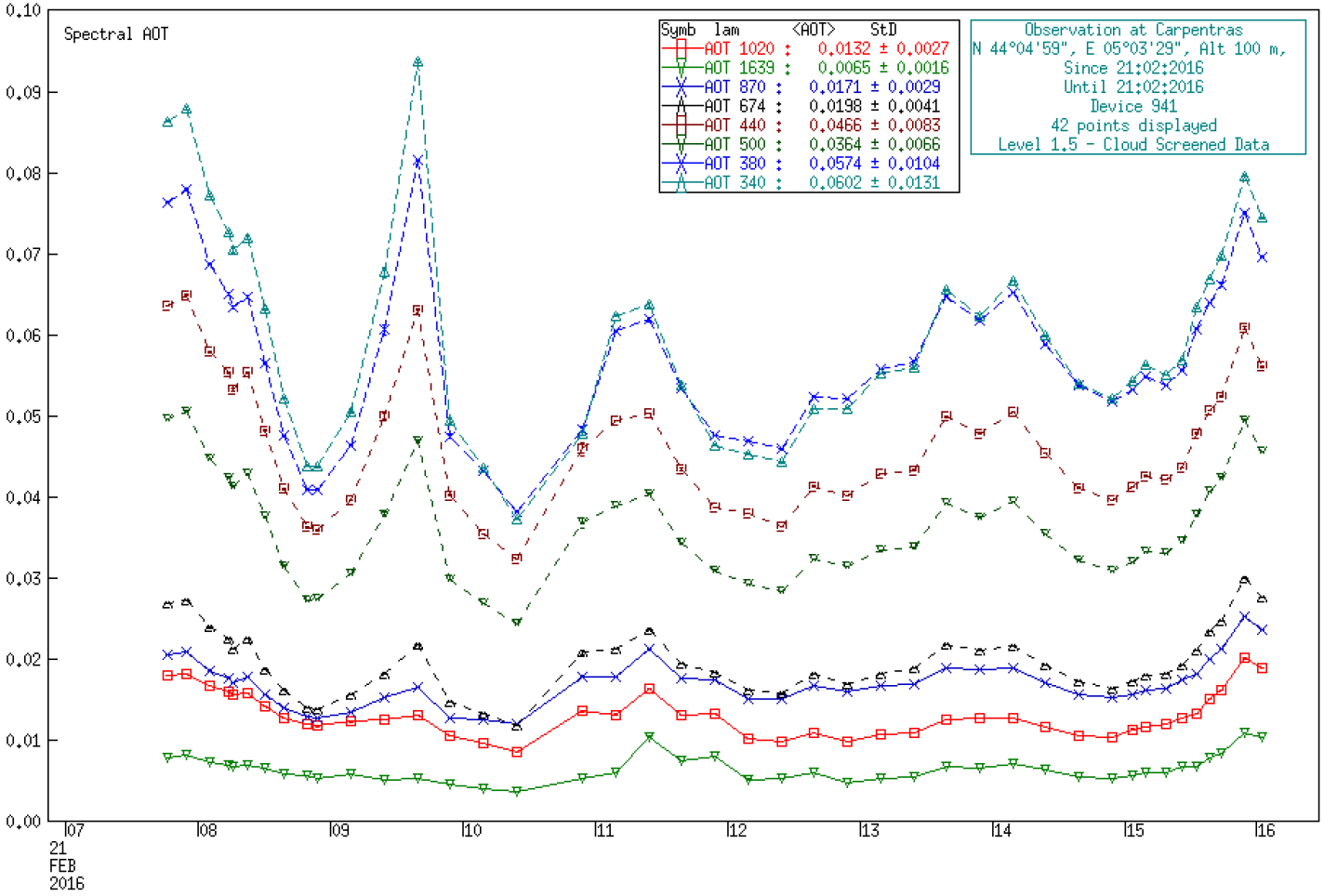
Sun Langley (at 1020 nm) at Izana (2470 m a.s.l)



- $\Delta Vo/Vo$ = 0.25 to 0.5 %
- Freshly calibrated couple of Reference instruments : every 3 months

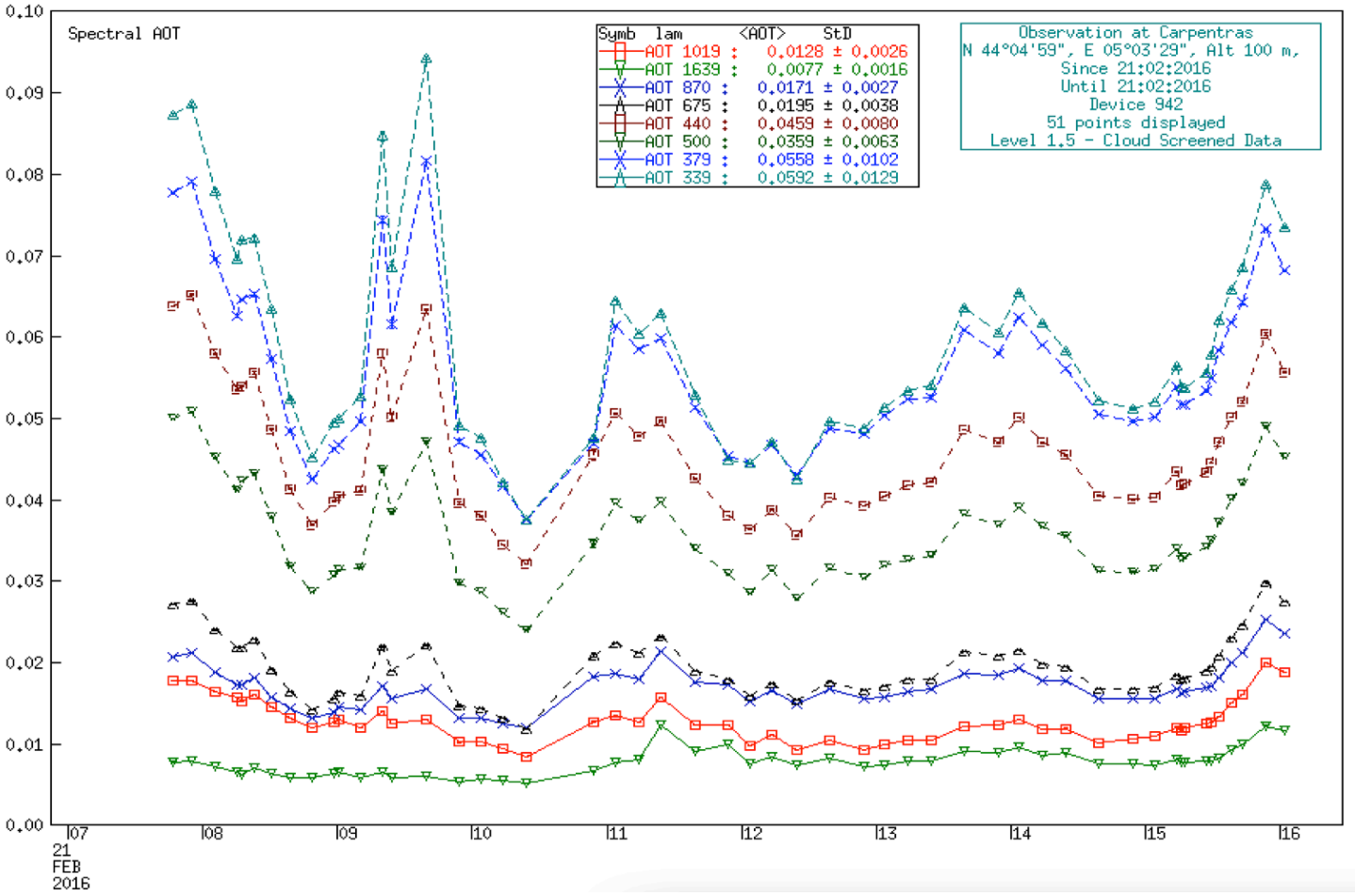
Master # 941 (at Carpentras)

AOD (< 0.1)



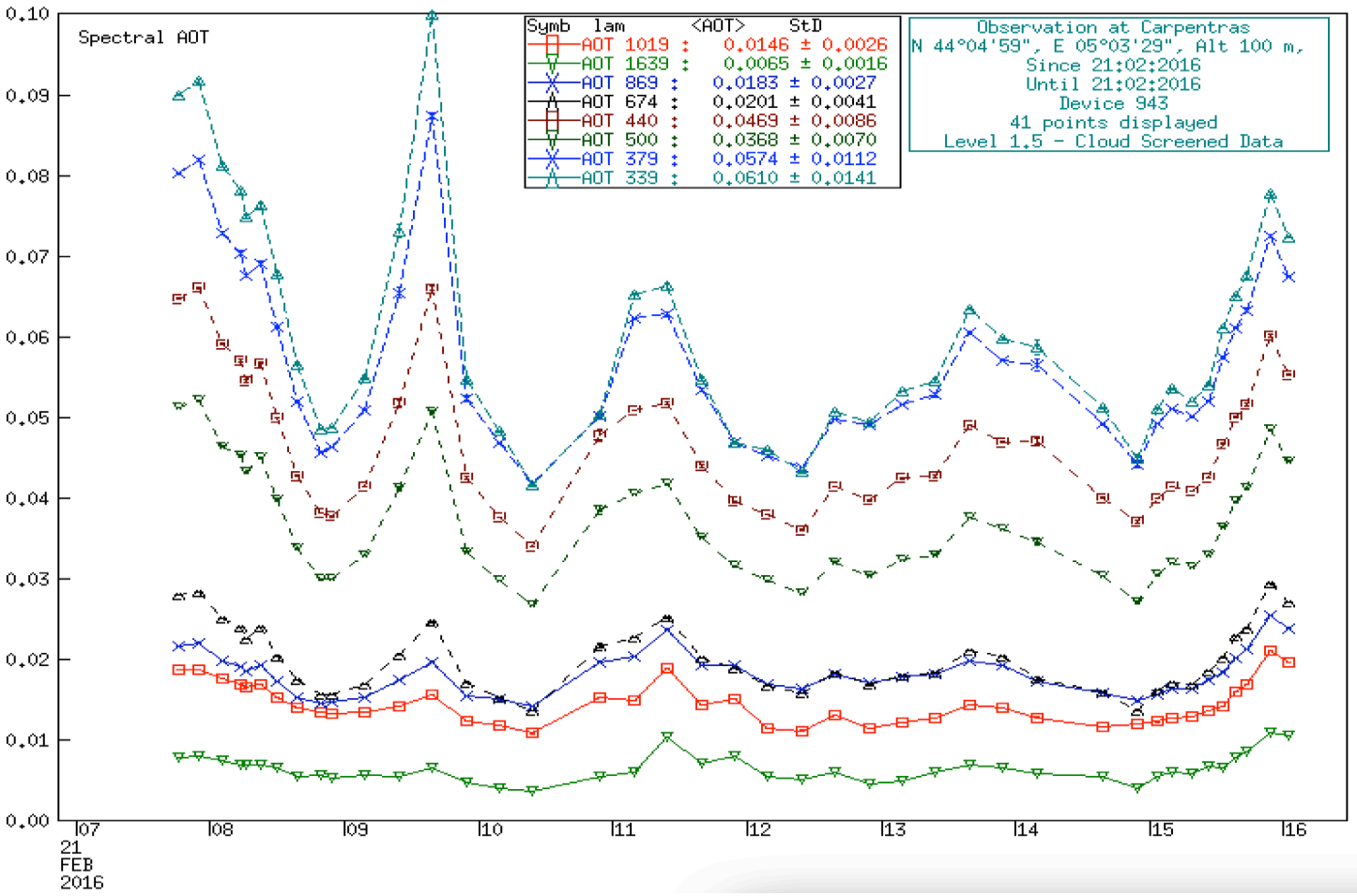
Master # 942 (at Carpentras)

AOD (< 0.1)

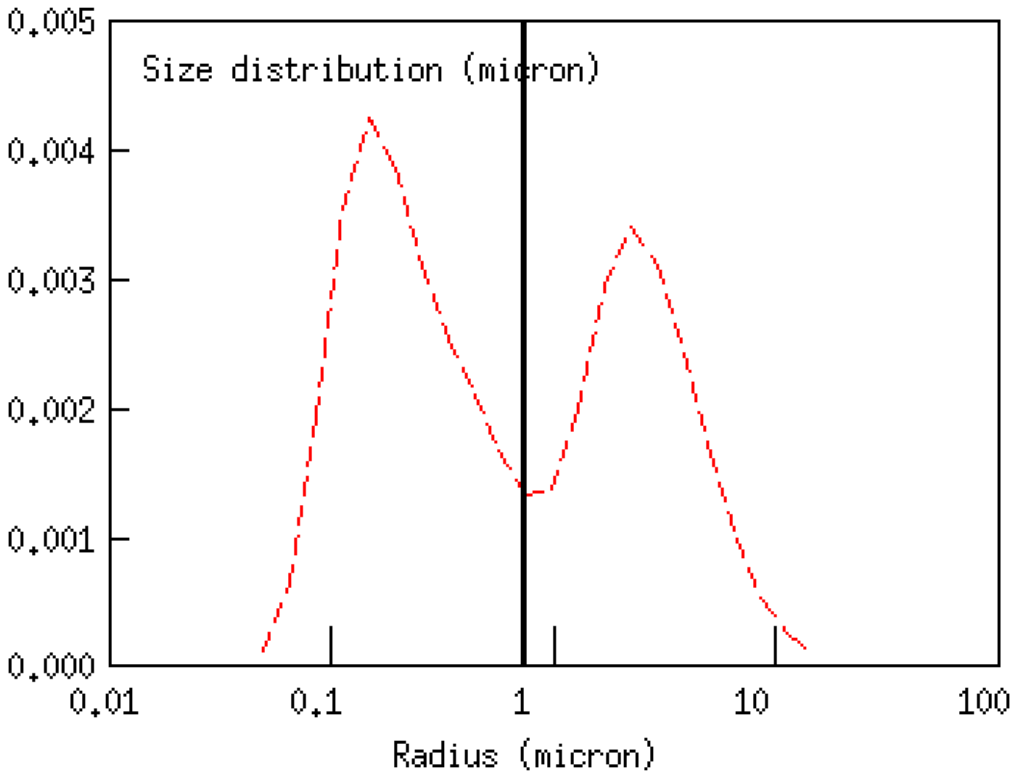


Master # 943 (at Carpentras)

AOD (< 0.1)

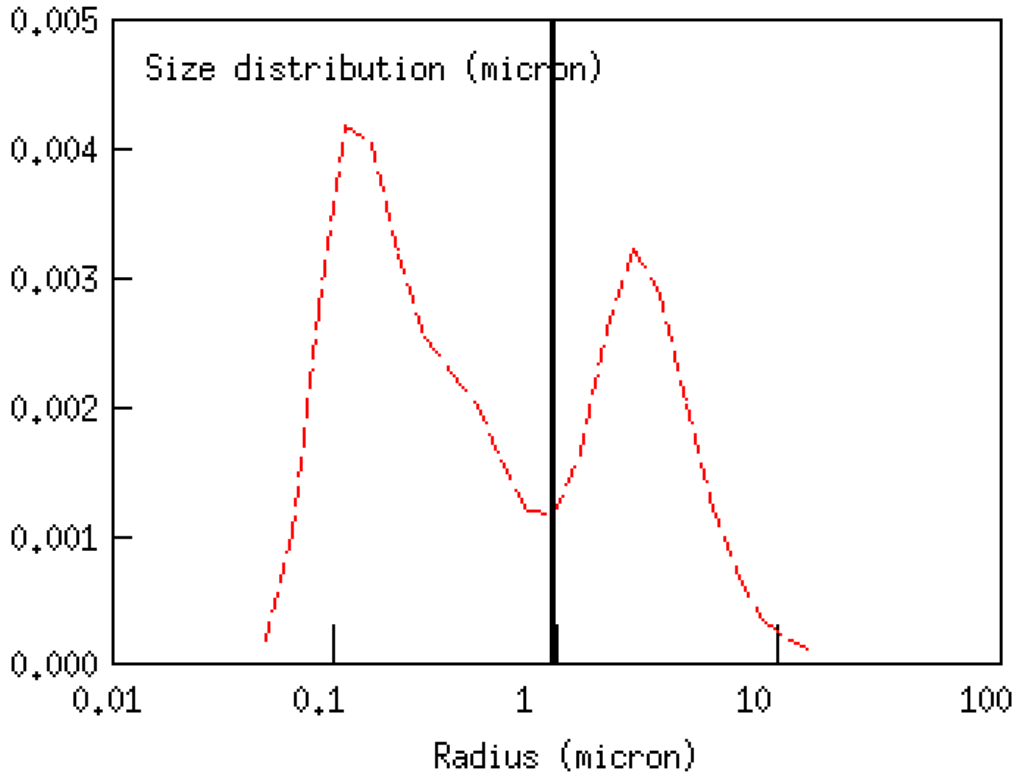


Retrieved Size Distribution (# 941) - Low AOD -

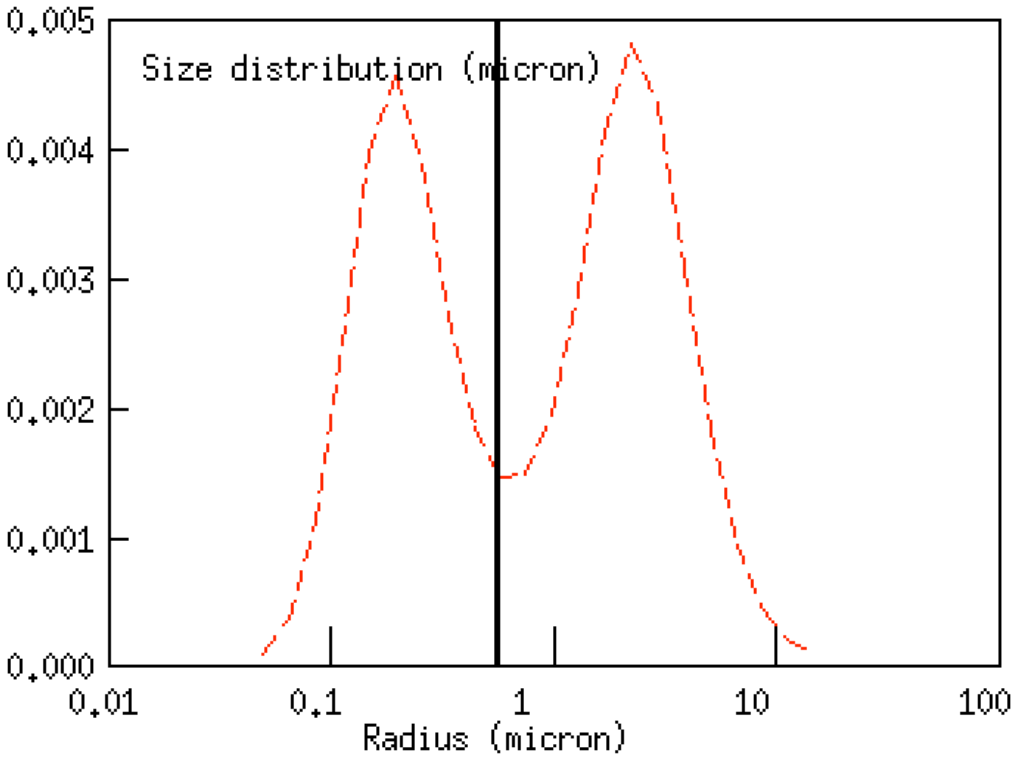


Retrived from AOD and Sky radiance inversion

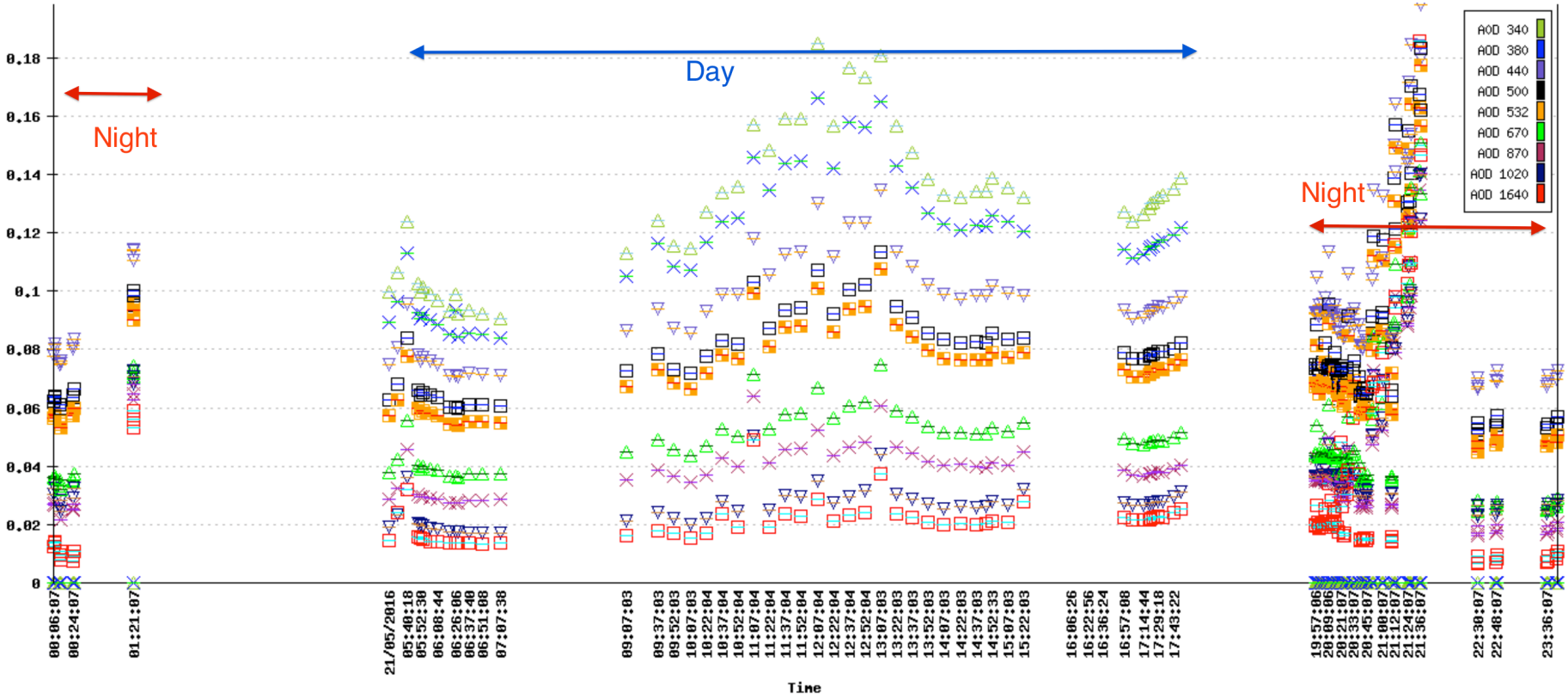
Retrieved Size Distribution (# 942) - Low AOD -



Retrieved Size Distribution (# 943) - Low AOD -



Day and Nightime AOD



Daytime and nighttime AOD measured at Carpentras calibration site, May 21th, 2016. It must be noted that no UV AOD are available during night.

Sky radiance calibration : link to NASA

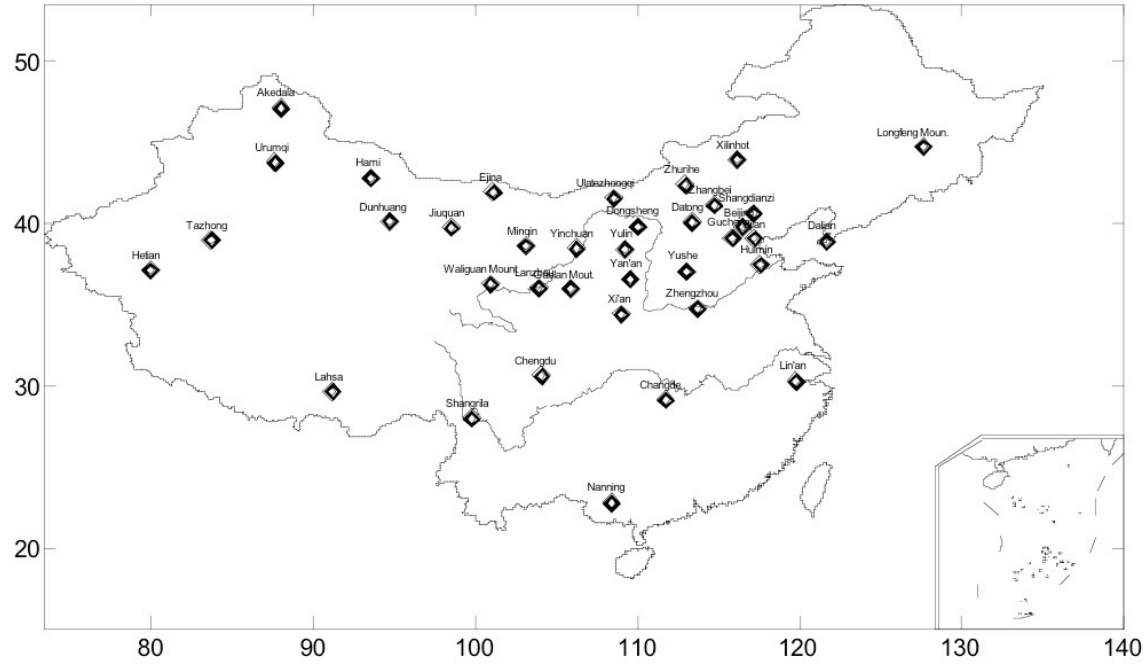
Every 3 month a reference instrument (travelling master) is sent to Europe (France and Spain).

=> Link to NASA reference calibration sphere

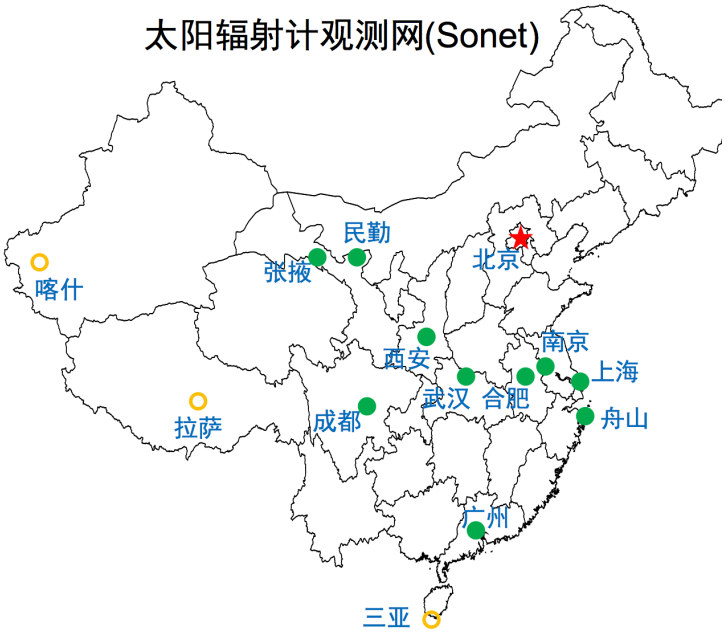
Direct-Sun and Sky radiance calibration : link with China

CIMEL Master instruments belonging to CMA (**CARSNET**) and CAS (**SONET**) are regularly calibrated by AERONET Europe (several times / year).

CARSNET



SONET



=> Bridge and traceability between Chinese and AERONET sky and sun calibration

Direct-Sun calibration : link with GAW/PMOD (PFR)

1- 2006 Campaign at Davos (LOA), GEOMON/FP7 Project :
Max difference (at 380nm) < 0.0047 (132 days) for Master and < 0.008 (for Field)

2- 2015 Campaign at Davos (AERONET-Europe, Nasa, …)
Max difference (at 380nm) < 0.007 ((1 or 2 weeks) for Master and Field

3- Long term comparison 2004-2012 at Izana (Romero et al. In prep).
Max Difference < 0.0065 (AOD < 0.1) with no trend on AOD and AE.

Objective : Existing coincident measurements for CIMEL and PFR (Izana and Davos)
Project of NRT continuous comparison (monitoring)

Conclusions and future plans

Deliverable WP 3440-1 :

Technical report «**Upgrade of the AERONET Europe Calibration Facility for sun and moon photometer"** **Done**

Practically: IDEAS/phase 1 is the first direct support from ESA to the European AERONET activity and developpement : Calibration units

This first contribution is particularly relevant for consolidating/building the european capacity and more precisely in the framework of the Atmospheric Infrastructure ACTRIS-RI. AERONET-Europe will be one of the 5 Central Facilities, core of the ACTRIS-RI (long-term investments 20-25 years from now).

ACTRIS-RI is entering in its Preparatory Phase (pre-operational in 2019-2010)

From now to 2020, it is very important to consolidate (upgrate instruments, facilities, introduce innovation (methodologies, instruments, processing (GRASP) to build up a strong and efficient Central Facility and provide high quality data and services

IDEAS-Phase 2

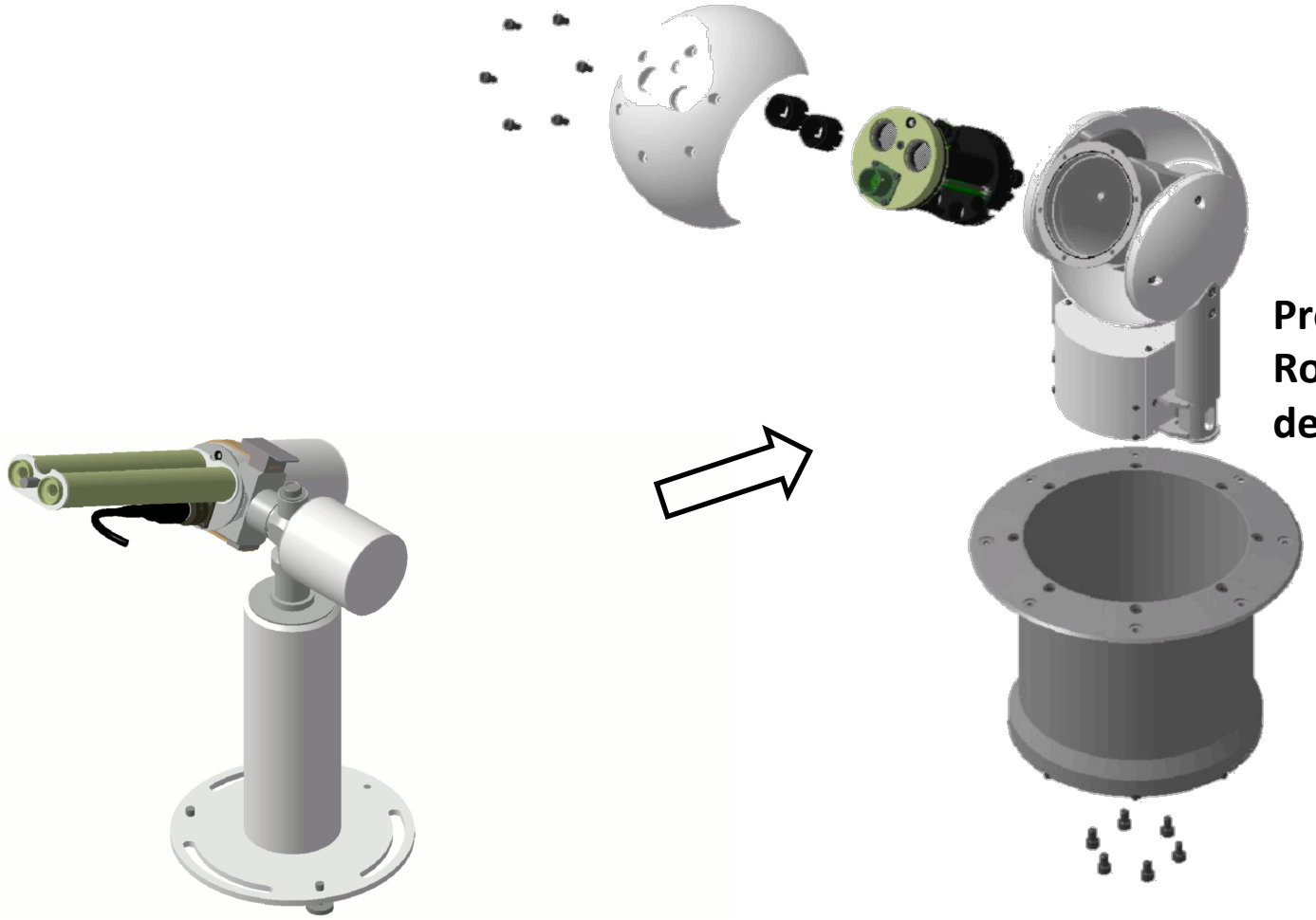
This second phase will provide additionnal support :

- to upgrade robots for calibration sites (new robots, better, faster)

-to design and build a new prototype robot for mobile sun(/sky) photometry (PLASMA instrument), coop. LOA/ CIMEL SME

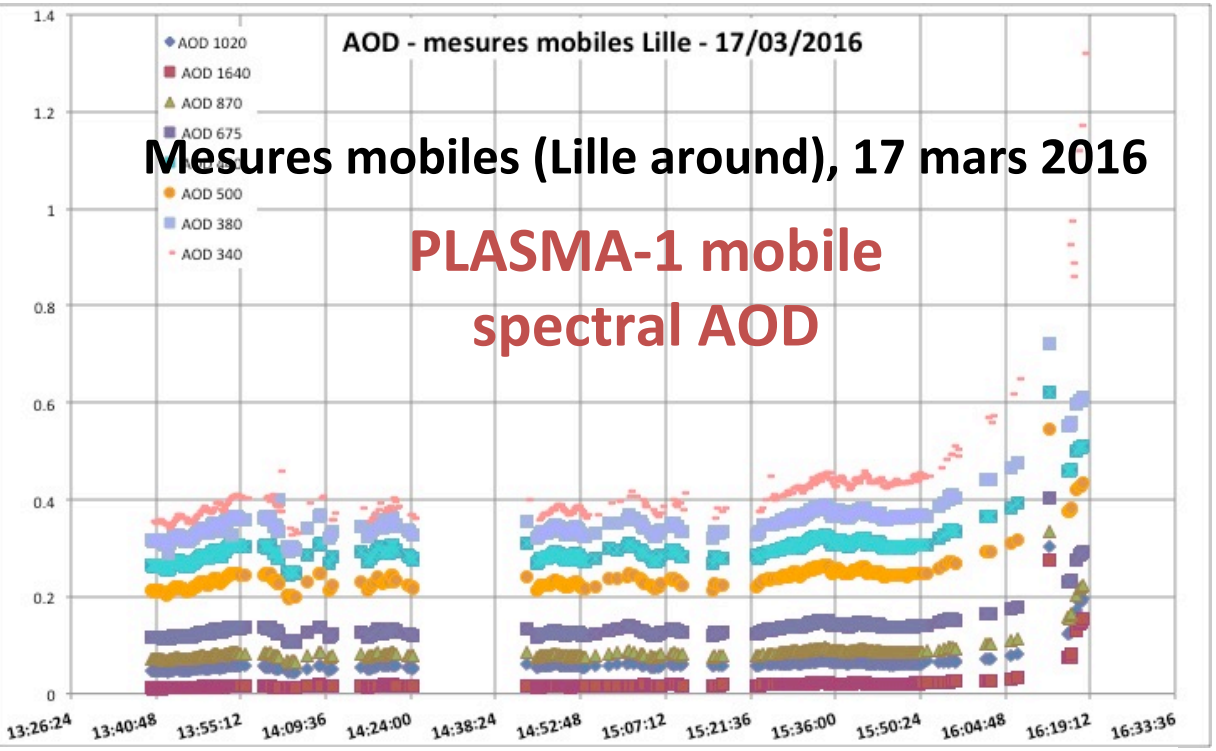
(Mobile : AOD acquisition during motion (car, plane, boat, …))

PLASMA-3



Prototype Robot to be designed in LOA

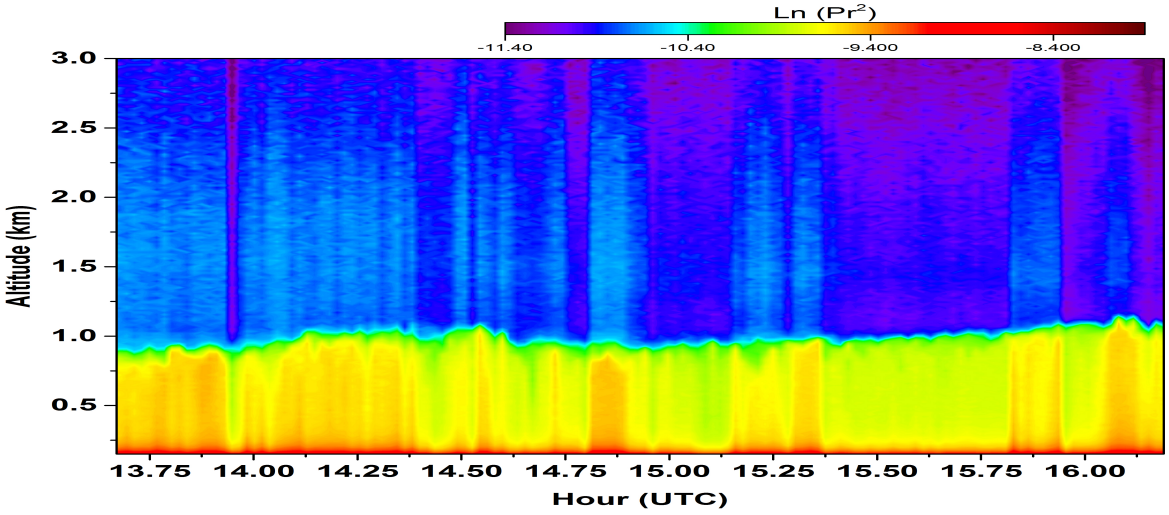
Mobile Calibration/Validation Facility



Mesures mobiles (Lille around), 17 mars 2016

PLASMA-1 mobile spectral AOD

→ Time/space



The coming DIVA (ESA) project involves relevant activities on methodological (instrument and processing) is quite consistent with ACTRIS-RI preparation.

Any additionnal support from ESA to AERONET Europe (instrumental upgrade) during ACTRIS-RI preparatory phase is quite welcome !

Thank you !