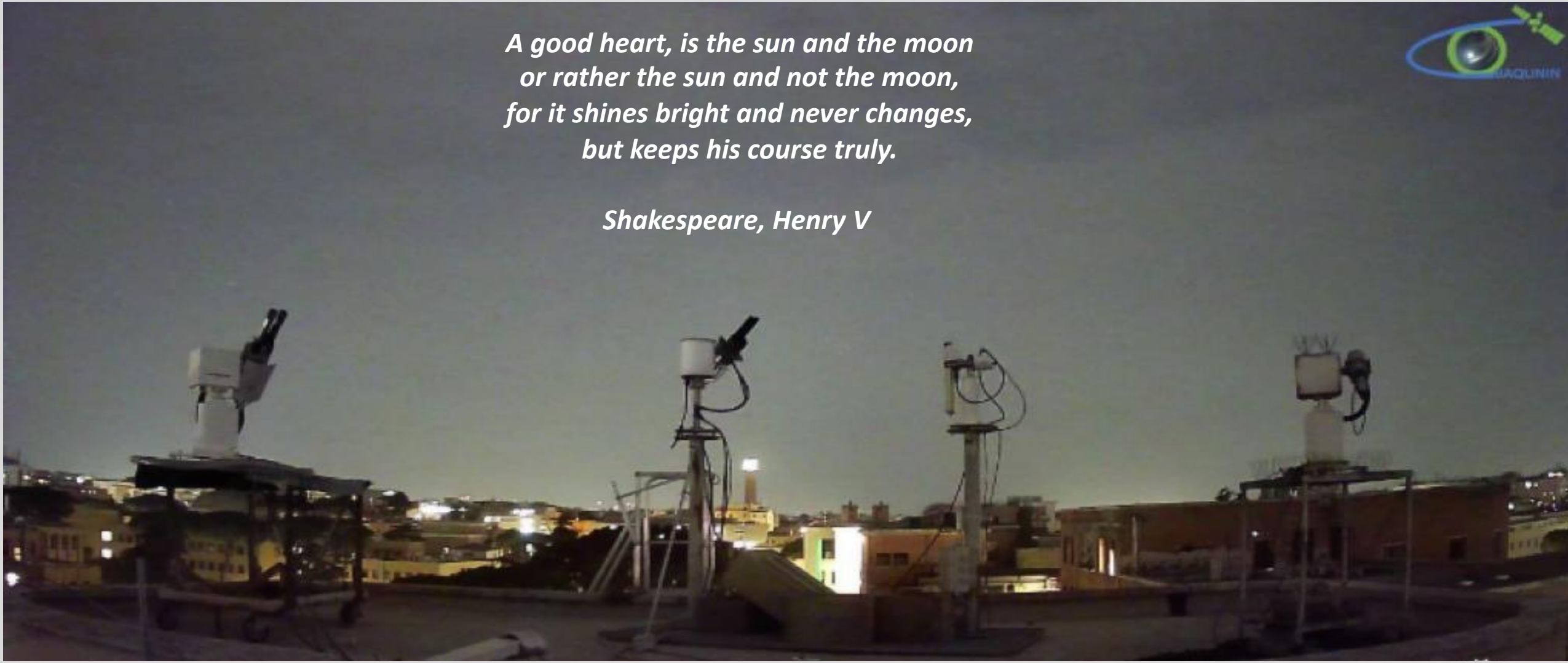
The Skynet network for the retrieval of aerosol properties from the moon irradiance measurements

M. Campanelli (ISAC- CNR, IT) , G. Kumar and V. Estelles (UV, SP), A. Uchiyama and T. Matsunaga (NIES, JP),

A. Iannarelli, S.Casadio, G. Mevi, N. Ferrante (SERCO, IT), A. Di Bernardino (U. SAPIENZA, IT)



Fourth Joint GSICS/IVOS Lunar Calibration Workshop, 4-8 December 2023, Darmstadt, Germany

Overview

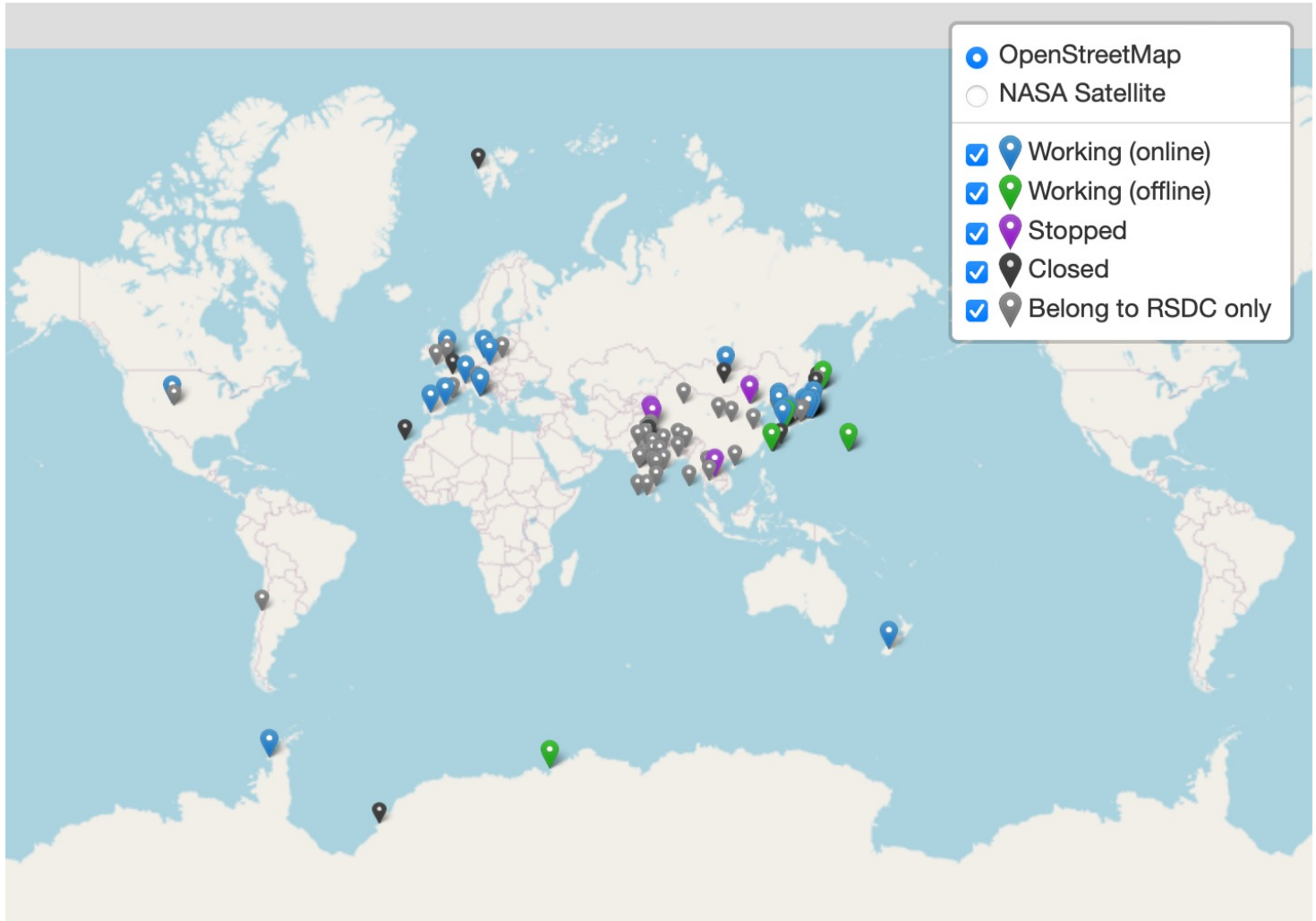
International SKYNET DataCenter

(https://skynet-isdc.org)

Skynet is a network of sun-sky photometers aimed to the study of columnar aerosol properties.

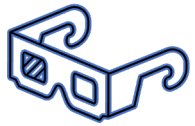
more than 100 sites worldwide located

some of them co-located with AERONET and PMOD/WMO.



International
SKYNET DataCenter

Home | About SKYNET | Product & Method | Observation sites | Quicklooks | Data Download | Data policy | Meetings | Links



https://www.skynet-isdc.org/quicklooks_ESR-mri.php#LLindenberg

- ISDC implements 2 data analysis flows (**SR-CEReS** & **ESR-MRI**) and provides standard products by the above two data analysis flows.
- The products can be downloaded from the web page
- AOD at wavelengths of 340, 380, 400, 500, 675, 870, 1020 nm
- Single Scattering Albedo (SSA) at the same wavelength of AOD
- Refractive index (RI) at the same wavelength of AOD
- Volume size distribution of aerosols(dV/dlnr)
- Angstrom exponent

For POM01

Half view angle	0.5°											
Min. Scattering angle	0,2,3,4,5,7,10,15,20,25,30,40,50,60,70,80,90・・・・180（°） [*Max. 180°]											
Band width 50%	10nm											
Wavelengths (nm)	Monitor Channel	1	2	3	4	5	6	7	8	9	10	11
	Wavelength (nm)	315	340	380	400	500	675	870	940	1020	1627	2200
	*Channel 0 is a dark value. 940 nm is a water vapor absorption band											
Channel Setting	Filter wheel type											
Detector	Short wave length (315nm~1020nm)	Si Photodiode : Hamamatsu Photonics										
	Long wave length (1627nm, 2200nm)	InGaAs Photodiode : Hamamatsu Photonics										
Range	2.5mA , 125A , 6.25uA , 312.5nA , 15.62nA , 781.2pA , 39pA *Auto Control											
Temperature Control and Measurement	20℃ (heating control only) Measurement range : Short λ : 0 to 50degC, Long λ : 0 to -25degC. Option : Cooling Unit (* λ =Wavelength)											
Control Structure	Stepper motor: Azimuth / Zenith angle-2 axes Motor step: 0.0036 ° / pulse											
Tracker range of motion	Azimuth	± 300 ° (0 ° to the south)										
	Zenith	-60 to 160 ° (horizontal 0 °)										
Position sensor	4-element Si sensor: Made by Hamamatsu Photonics * See attached sheet											
Raind sensor	AKI-1801 * See attached sheet											
Communication	RS-232											
Power consumption	200W (100V/2A)											
Power supply	100 to 240 VAC /2A(50/60Hz)											
Weight	Skyradiometer / Approx. 20kg											
	Cable : Approx. 4kg/20m(Standard)											
Accessories	Power Cable (Standard 20m) Communication cable (20m: standard) * Long-distance transmission cable up to 100m is possible Rain Sensor Shield Tool BOX (equipment fixing bolt screw, hexagon wrench, self-adhesion tape, silica gel) CD-ROM ・CD-ROM (For observation software) Case for Sensor tube											

The standard instrument of Skynet is the POM produced by the Japanese PREDE Company:
since few years is building a new model for measuring both sun and moon irradiance

The moon-network status

Model	Location	Operation time	PI
POM02	Rome – downtown, IT	Since May 2022	Sapienza University
POM01	Rome – Tor-Vergata, IT	Since August 2023	ISAC-CNR
POM02	Baltic sea coast-Zingst, GE	Not yet available	DWD
POM01	Campaigns: Rome, IT Davos, SW Izana, SP	 September 2021 October 2021 September 2022	ISAC-CNR
POM02	Valencia, SP	Planned 2024	Univ. Valencia
POM02	Aosta, IT	Planned	ARPA-VDA
POM01	by PREDE for update	/	ISAC-CNR

Projects involvement

IDEAS - QA4EO: Quality Assurance for Earth Observation

WP no.	Task
	Task 2 - R&D Cal/Val and Metrology
2323	Night-time aerosol and trace gases columnar observations in Urban Environment - CNR-ISAC (Rm)

MAPP

Obj. 1: Radiometric characterisation and calibration of sun photometers and spectroradiometers

Obj. 2: Determination of TOA lunar and solar spectra

Obj. 3: Development of a comprehensive uncertainty budget for aerosol optical properties from remote sensing data

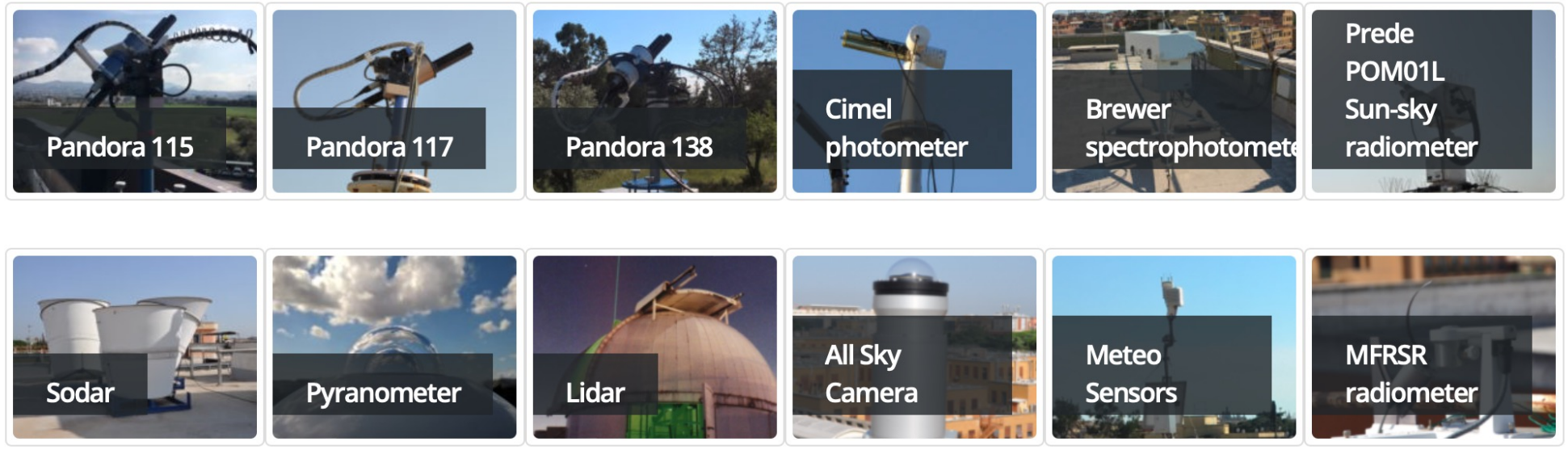
EUMETSAT FRM4AER.

This Service proposal is focused on the current and future aerosol retrieval products provided by EUMETSAT from the SLSTR and/or OLCI instruments onboard Sentinel-3, the CO2M-MAP instrument to support the greenhouse gas retrievals (and associated aerosol correction) and further aerosol products from SEVIRI as well as from PMAP (METOP instruments).

all Skynet and Aeronet data will be used to validate AOD from Sentinel 3

BAQUNIN

Boundary-layer Air Quality-analysis Using Network of Instruments Super Site



HARMONIA
International network for harmonization of atmospheric aerosol retrievals from ground based photometers

International network for harmonization of atmospheric aerosol retrievals from ground-based photometers

pmod wrc

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the European Union

What is COST ? What is funded ?

Founder: European Cooperation in Science & Technology

COST provides networking opportunities for researchers and innovators in order to strengthen Europe's capacity to address scientific, technological and societal challenges

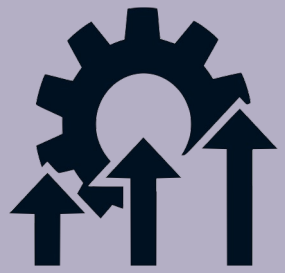
HARMONIA
International network for harmonization of atmospheric aerosol retrievals from ground based photometers

Networking Action

+ dissemination

WG1
Aerosol measurement homogenization

WG2
Aerosol measurement improvement



WG3
End user engagement towards maximizing aerosol measurement use

WG4
Industry engagement towards innovative hardware, software products

Harmonia

Nov. 2022 – Oct. 2026

Action Chair: Stelios Kazadzis

Grant Holder: PMOD-WRC

Core Group 16 people-7 countries

Participants: 118 ppl., 44 countries

Budget: ~200K/ year

WG2:

- Suggest **improvements** for solar, lunar and star photometry measurement quality based on **exploiting past datasets**
- **Link lunar and stellar calibration with solar retrievals** exploiting databases of experimental campaigns of the past

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY
Funded by the European Union

Joining Harmonia

https://www.cost.eu/actions/CA21119/

https://harmonia-cost.eu/

@HARMONIA_COST

CA21119 - International network for harmonization of atmosphe ground based photometers (Harmonia)

Downloads

Home > Browse Actions > International network for harmonization of atmospheric aerosol retrievals from ground based photometers (Harmonia)

Description | Management Committee | Main Contacts and Leadership | **Working Groups and Membership**

Working Groups

Number	Title	Leader
1	Homogenization of established techniques and existing tools	Dr Lionel DOPPLER
2	Improvement of aerosol products	Dr Monica CAMPANELLI
3	End user engagement towards maximizing aerosol measurement use	Dr Stavros SOLOMOS
4	Industry engagement towards innovative hardware, software products	Dr Natalia KOUREMETI
5	Project results dissemination	Dr ANCA NEMUC

Express your interest to join any of the working groups by applying below.

It is required to have an e-COST profile to submit your application. If needed, create it first and then click 'Apply'.

Apply

SKY OVER BERLIN

HARMONIA

2024 TRAINING SCHOOL ON AEROSOL MEASUREMENTS

8-10 April 2024

Berlin - Lindenberg

- IN FU BERLIN AND DWD LINDENBERG
- LECTURES BY EXPERTS
- SMALL GROUPS WORKSHOPS
- AVAILABLE TRAVEL FUNDING

DETAILS AND REGISTRATION
HTTPS://HARMONIA-COST.EU/

DWD

cost
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FREIE UNIVERSITÄT BERLIN

pmod wrc

HARMONIA

Method

Atmos. Meas. Tech., 12, 6465–6488, 2019
https://doi.org/10.5194/amt-12-6465-2019

Atmospheric Measurement Techniques
Open Access
EGU

Nocturnal aerosol optical depth measurements with modified sky radiometer POM-02 using the moon as a light source

Akihiro Uchiyama[1], Masataka Shiobara[2], Hiroshi Kobayashi[3], Tsuneo Matsunaga[1], Akihiro Yamazaki[4], Kazunori Inei[5], Kazuhiro Kawai[5], and Yoshiaki Watanabe[5]

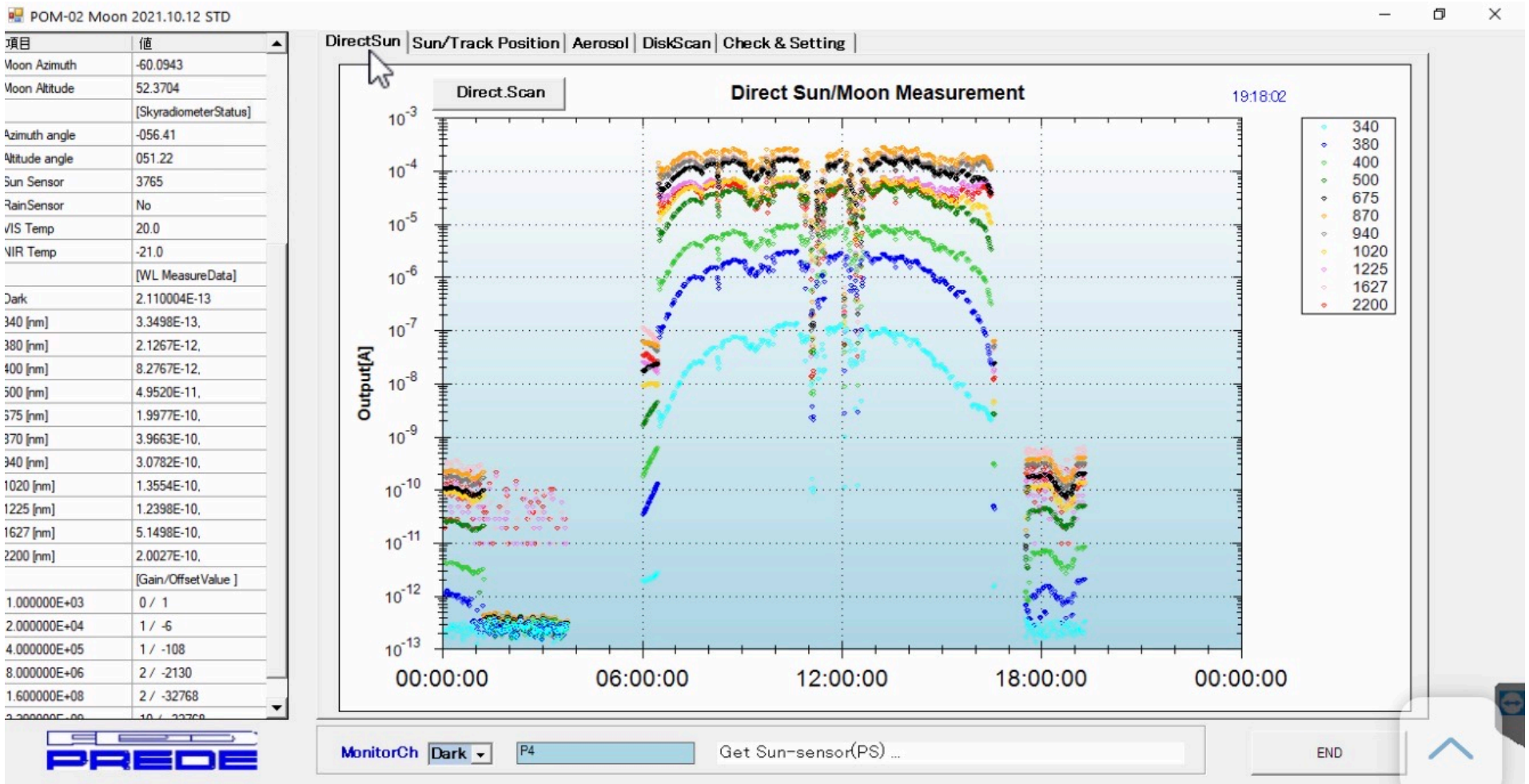
- Modification of the POM Sun model => change of amplification and position sensor
- After Amplification: good measure at 340 and 380 nm, difficult at 1225, 1627 and 2200 nm (SWIR)
- 4 quadrants photodiode for MPA [+90°,-90°]; then by software (Nagasawa 1981) up to 120°=> good comparison with SPICE (<0.01°in zen; <0.04° in Az)
- Reflectance from ROLO is considered, not transformed in Irradiance
- Reflectance at wls of POMs are obtained by linear interpolation of the 2 closest ROLO wl (extrapolation for 340 nm)

Type of measurements: **Direct Sun**, **Direct Moon**, **Almucantar and Pricipal plane Sun**, **Almucantar Moon**

The measurement of scattered light around the moon is controlled by Prede software and it is performed when several conditions (altitude of the sun, altitude of the moon, and the output value of the moon sensor) are met.

The maximum scattering angle is user defineble : default maximum value = 30°.

Personal comunication of Dr. Uchiyama: data up to 5° can be used to remove the scattered light affecting the direct measurement and it may be used to determine the presence or absence of clouds



$$V(\lambda_0) = V_{m0}(\lambda_0)\exp\left(-m(\vartheta)\tau(\lambda_0)\right)T_{gas}(\lambda_0,\vartheta)$$

Measured Moon Direct Irradiance

Moon Irradiance at TOA

Moon optical arimass

AOD

Gas Transmittance

$$A_{ROLO} = \frac{V_{m0}}{\Omega_M V_{S0}}$$

Sun Irradiance at TOA

$$V(\lambda_0) = \frac{\tilde{A}_{\mathrm{ROLO}}}{\pi}\Omega_{\mathrm{M}}\frac{V_{S0}(\lambda_0)}{R_S^2}\cdot\frac{1}{R_{\mathrm{m}}^2}\exp(-m(\theta)\tau(\lambda_0))\overline{T}_{\mathrm{gas}}(\lambda_0,\theta),$$

ROLO smoothed Reflectance

Solid angle of the moon

Moon-sun distance

It is known that the AOD retrieved using the ROLO reflectance contains an error, which is dependent on the MPA (Barreto et al., 2016, 2017, 2019; Juryšek and Prouza, 2017).

It is assumed that there is an error in the ROLO reflectance and that the correct lunar reflectance is proportional to the ROLO reflectance => $A_{ROLO} = C^* A_{ROLO}$

This indicates that the relative variation in the ROLO model reflectance is assumed to be correct

$$V(\lambda_0) = \frac{C A_{\mathrm{ROLO}}}{\pi}\Omega_{\mathrm{M}}\frac{V_{S0}(\lambda_0)}{R_S^2}\cdot\frac{1}{R_{\mathrm{m}}^2}\exp(-m(\theta)\tau(\lambda_0))\overline{T}_{\mathrm{gas}}(\lambda_0,\theta),$$

$$\ln\left(\frac{\pi V(\lambda_0)}{A_{\mathrm{ROLO}}\Omega_{\mathrm{M}}}R_S^2 R_{\mathrm{m}}^2\right) = \ln C V_{S0}(\lambda_0) - m(\theta)\tau(\lambda_0)$$

$$= \ln V_{m0}(\lambda_0) - m(\theta)\tau(\lambda_0)$$

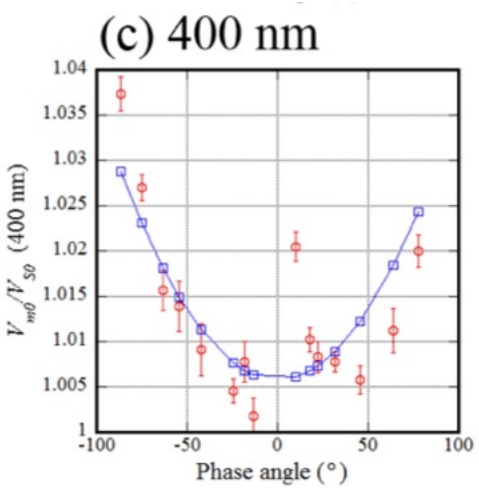
V_{m0} retrieved from the intercept

$$C = \frac{V_{m0}}{V_{S0}}$$

V_{S0} → retrieved from Langley plot

But C is dependent on MPA

…….But C is dependent on MPA



Measurements for Langley solar calibration were conducted at NOAA/MLO during the period from 28 September 2017 to 7 November 2017

$$C = A_c \cdot g^2 + B_c,$$

where g is the phase angle.

Table 3. Coefficients of the regression equation for reflectance correction factor C.

Wavelength (nm)	A_c	B_c	rms	No. of data
340	1.3404×10^{-5}	0.98027	0.0152	15
380	1.3512×10^{-5}	1.0674	0.0080	15
400	3.0760×10^{-6}	1.0058	0.0055	15
500	2.2487×10^{-6}	1.1600	0.0058	15
675	4.8644×10^{-6}	1.0840	0.0048	15
870	3.4967×10^{-6}	1.0855	0.0026	15
940	7.2405×10^{-8}	1.1532	0.0404	13
1020	6.7912×10^{-6}	1.0559	0.0078	15
1225	9.0288×10^{-5}	1.0572	0.0328	13
1627	2.3828×10^{-5}	1.0810	0.0237	13
2200	3.7545×10^{-6}	0.95311	0.0386	13

$C = A_c \cdot g^2 + B_c$. g: phase angle (degrees).

C calculation with Ac and Bc coefficients from the paper, g from SPICE

$$V_{new} = \frac{V \cdot \pi \cdot R_S^2 \cdot R_m^2}{C \cdot A_{ROLO}} = V_{S0} \cdot exp(-m\tau)$$

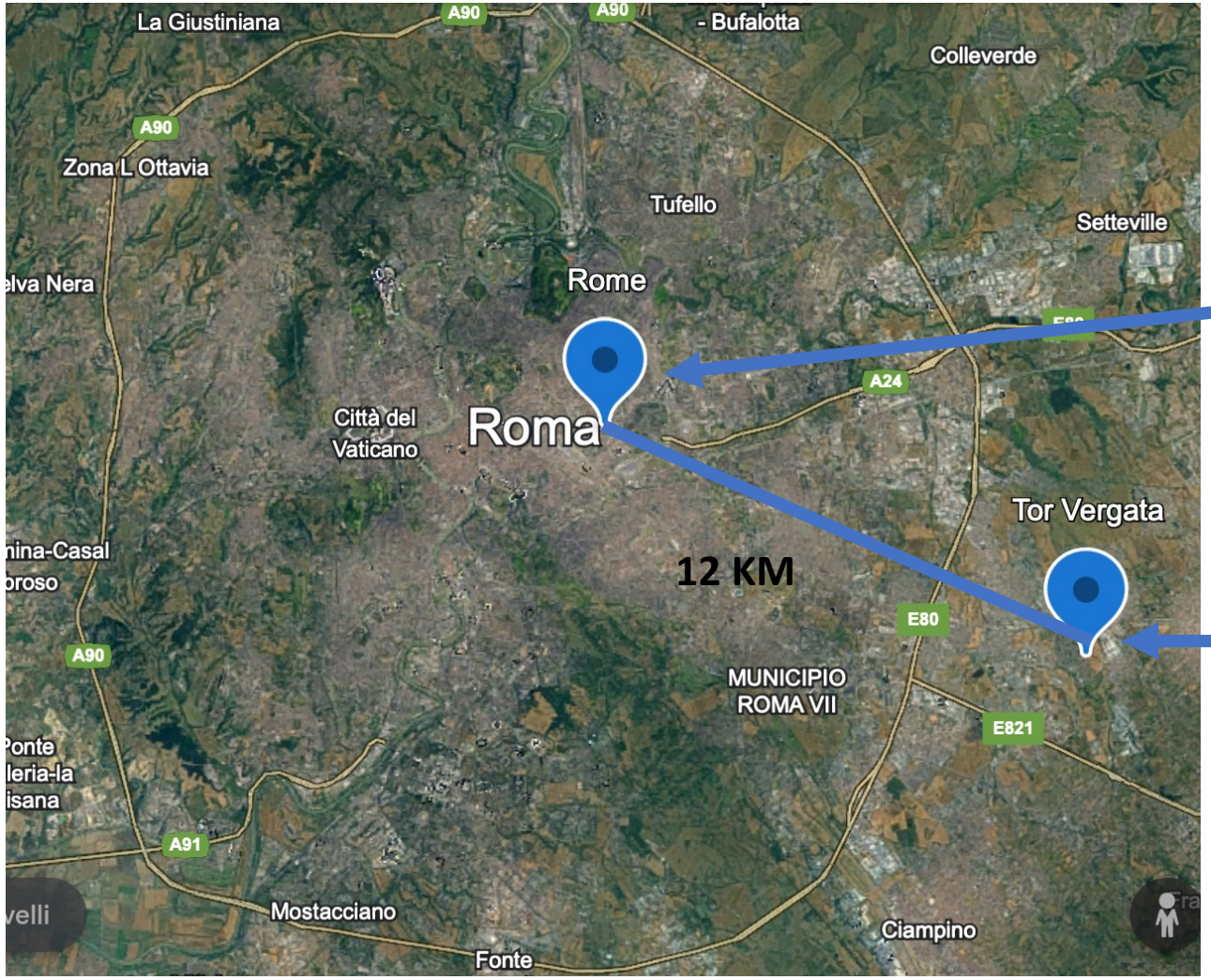
Triplet of V_{new} for Cloud screening

Calculation of AOD with SUNRAD code (Estelles et al., 2012)

Estelles et al, 2012. Atmos. Chem. Phys., 12, 11619–11630, 2012, www.atmos-chem-phys.net/12/11619/2012/ doi:10.5194/acp-12-11619-2012

RESULTS from the SKYNET network

AOD obtained for moon phases greater than 65%



SKYNET – LUNAR POM
AERONET –LUNAR CIMEL
only for QUATRAM campaign

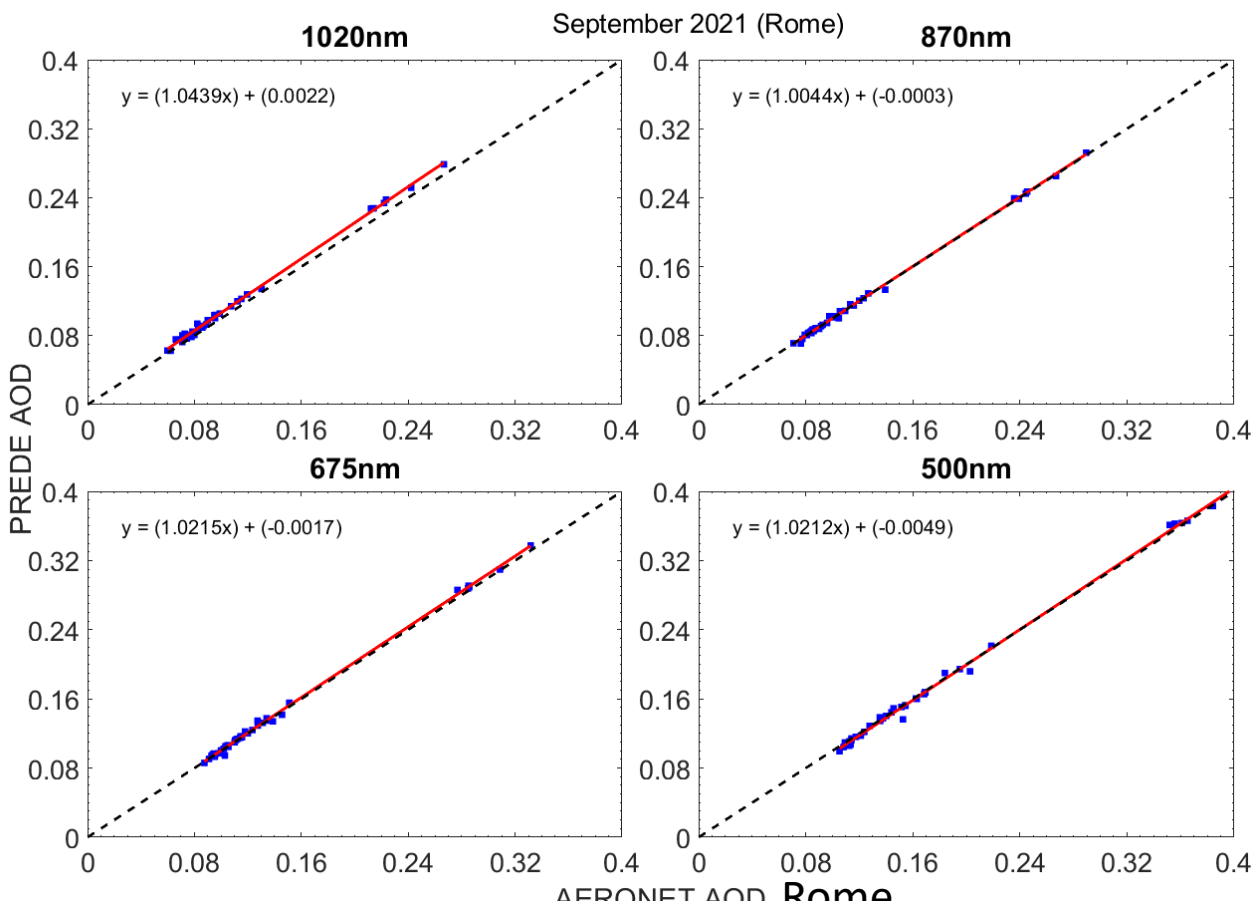
AERONET – LUNAR CIMEL

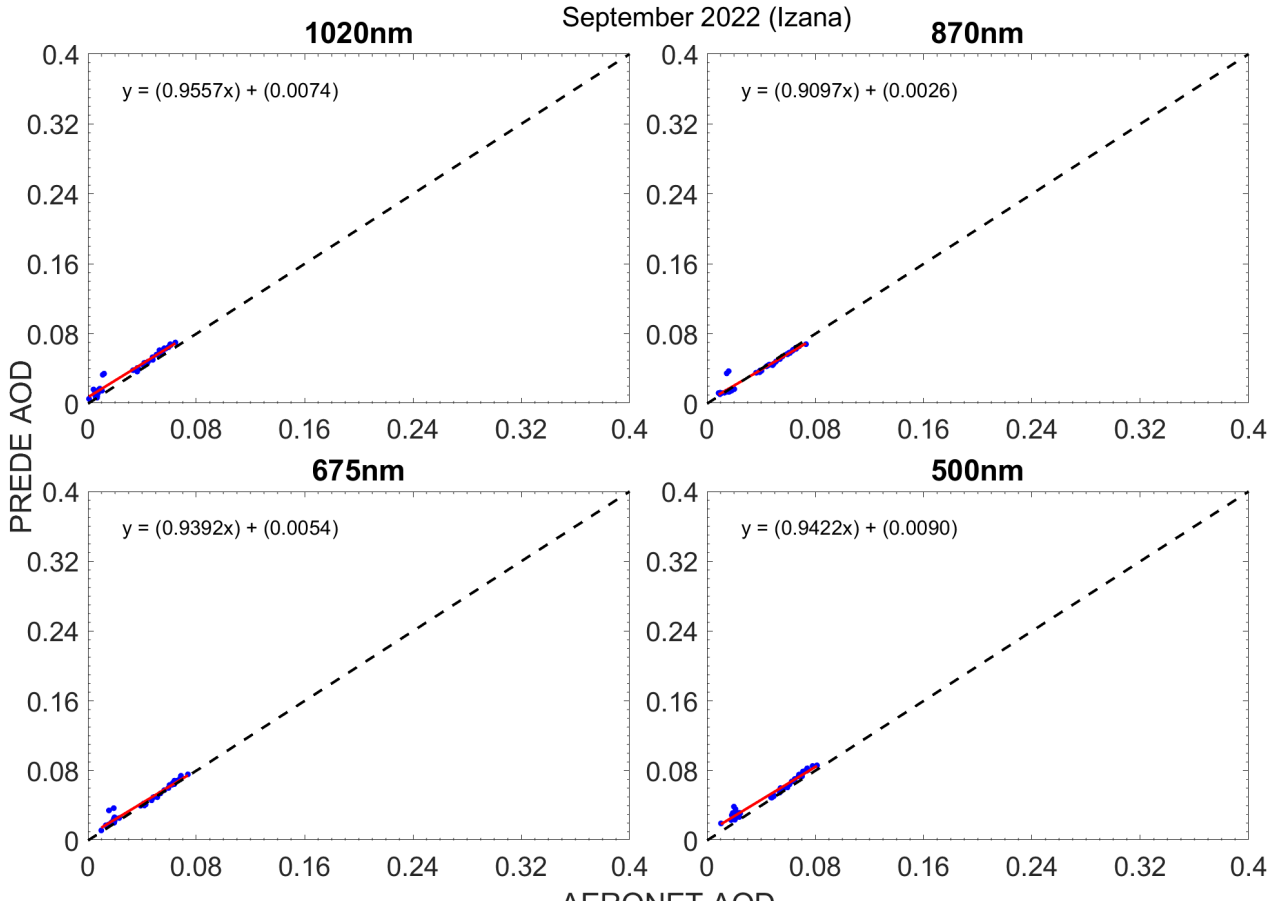
Retrieval and validation of night time Aerosol Optical Depth with a PREDE POM radiometer in the frame of two MAPP project campaigns

G. Kumar[1] , V. Estellés[1,2] , M. Campanelli[2] , A. Uchiyama[3] , M.P. Utrillas[1] , J. Gröbner[4]

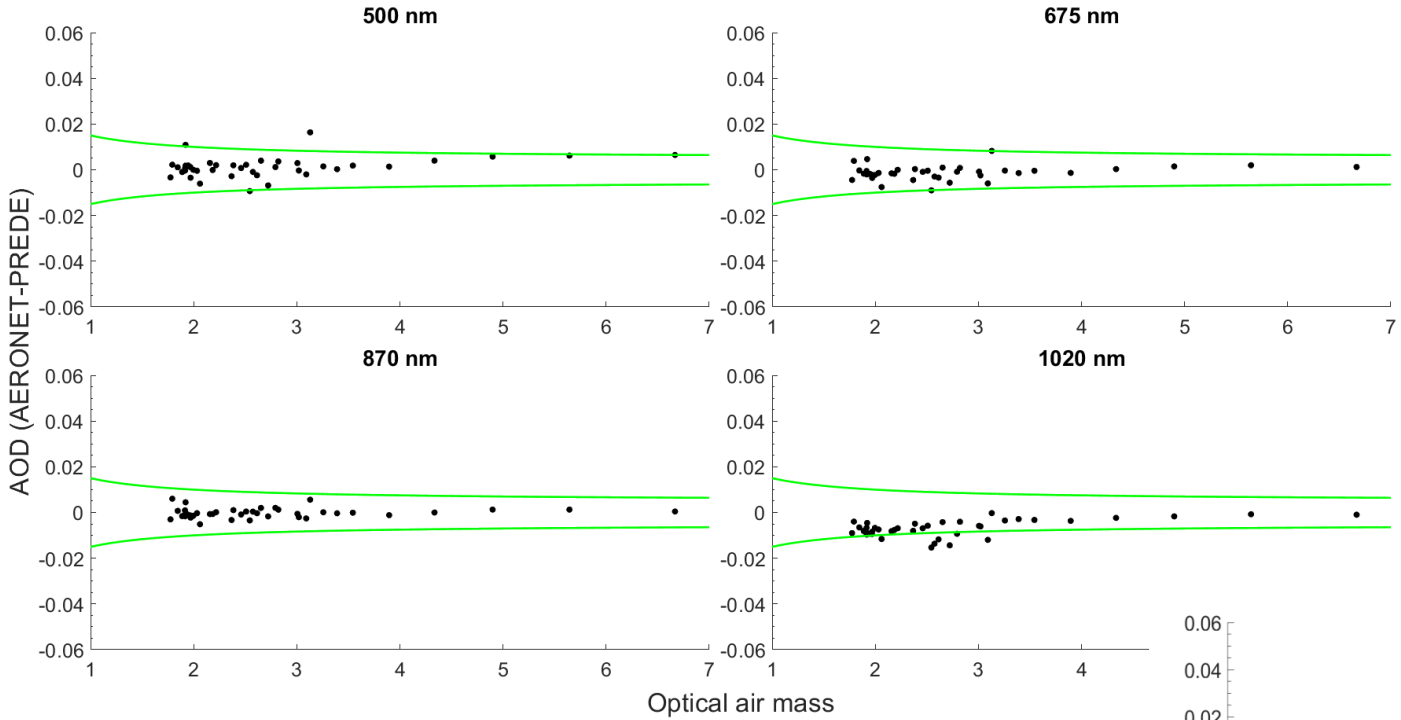
1 Department of Earth Physics and Thermodynamics, University of Valencia, Burjassot, 46100, Spain
2 Consiglio Nazionale delle Ricerche, Istituto Scienze dell'Atmosfera e del Clima, 100, 00133 Rome, Italy
3 Center for Global Environmental Research, NIES, Tsukuba, Japan
4 Physikalisch-Meteorologische Observatorium Davos, Switzerland
Presenting author email: gaurav.kumar@uv.es

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States



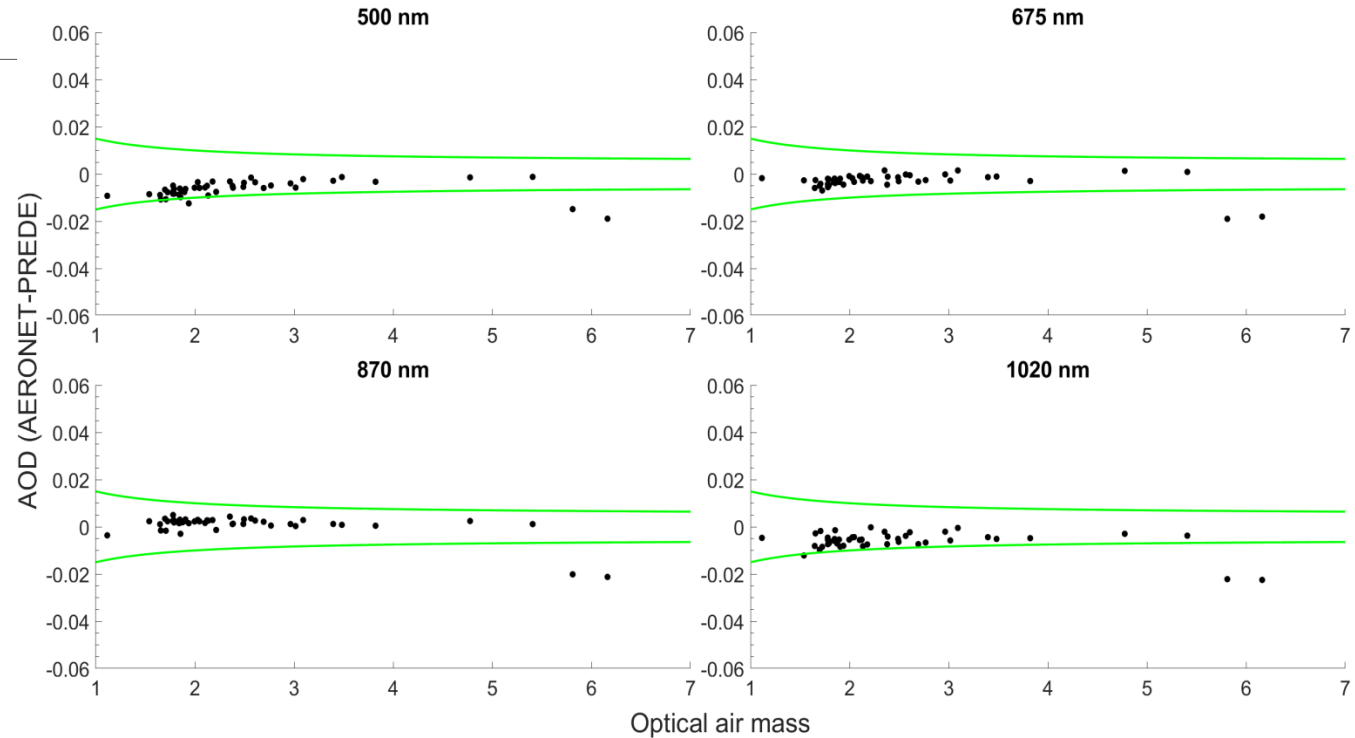


Rome



Green lines are the prescribed WMO limits (0.01/m±0.005, where m is the optical airmass).

Izana

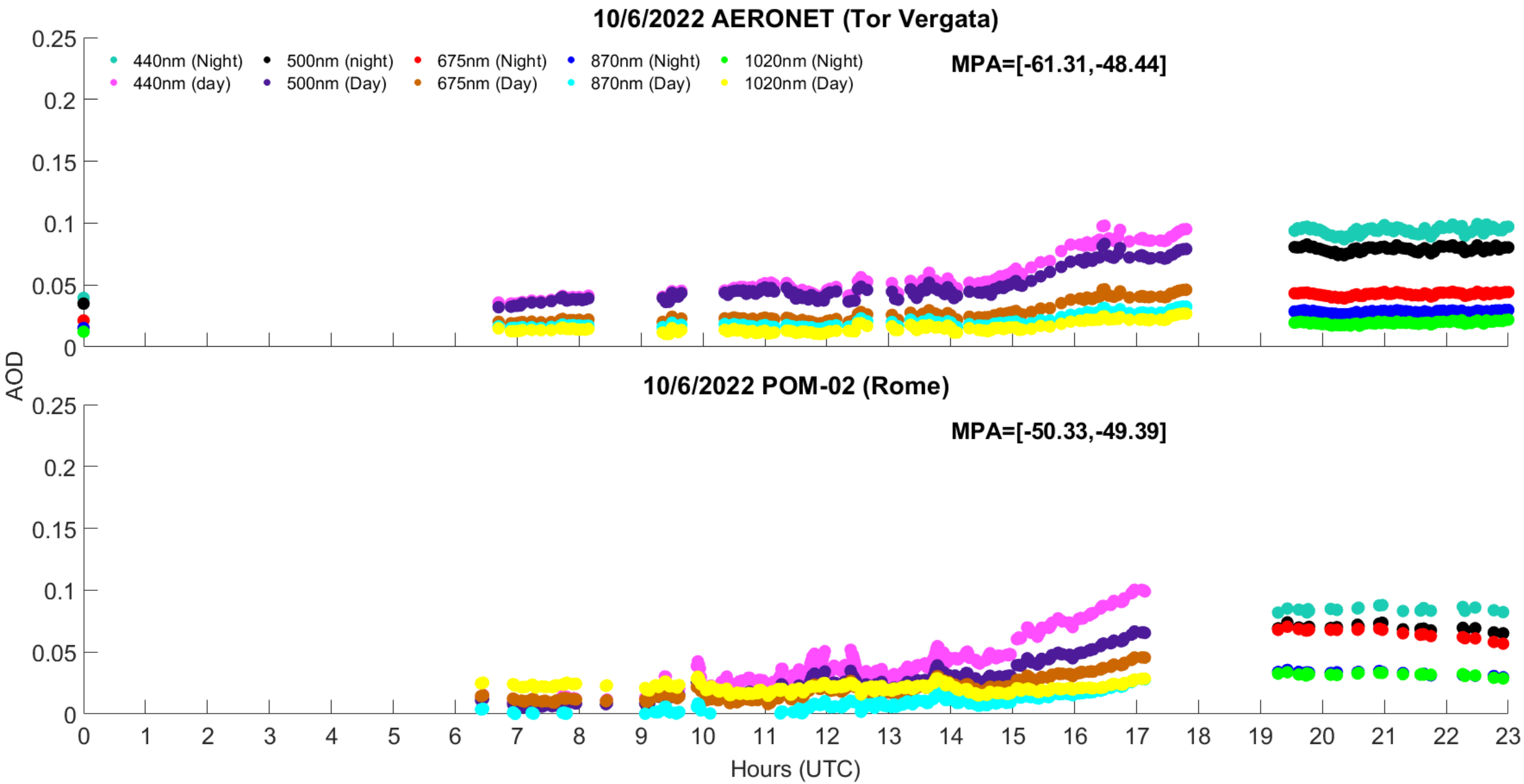


	500	675	870	1020
RMSD	0.0045	0.0033	0.0022	0.0078
Mean AOD from POM	0.1751	0.1404	0.1190	0.1133
Std	0.0896	0.0702	0.0600	0.0578

Statistics for QUATRAM 3 campaign , September 2021
Data: Lunar POM01 in Rome ; Lunar Cimel in Rome

	500	675	870	1020
RMSD	0.0310	0.0366	0.0187	0.0916
Mean AOD from Cimel	0.1242	0.0779	0.0567	0.0438
Std	0.0466	0.0302	0.0236	0.0213

Statistics for the the period June 2022 – September 2023
Data: Lunar POM02 In Rome; lunar Cimel in Rome Tor Vergata.


10/6/2022 AERONET (Tor Vergata)
440nm (Night)
440nm (day)
500nm (night)
500nm (Day)
675nm (Night)
675nm (Day)
870nm (Night)
870nm (Day)
1020nm (Night)
1020nm (Day)
MPA=[-61.31,-48.44]
10/6/2022 POM-02 (Rome)
MPA=[-50.33,-49.39]
AOD
Hours (UTC)
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0.05
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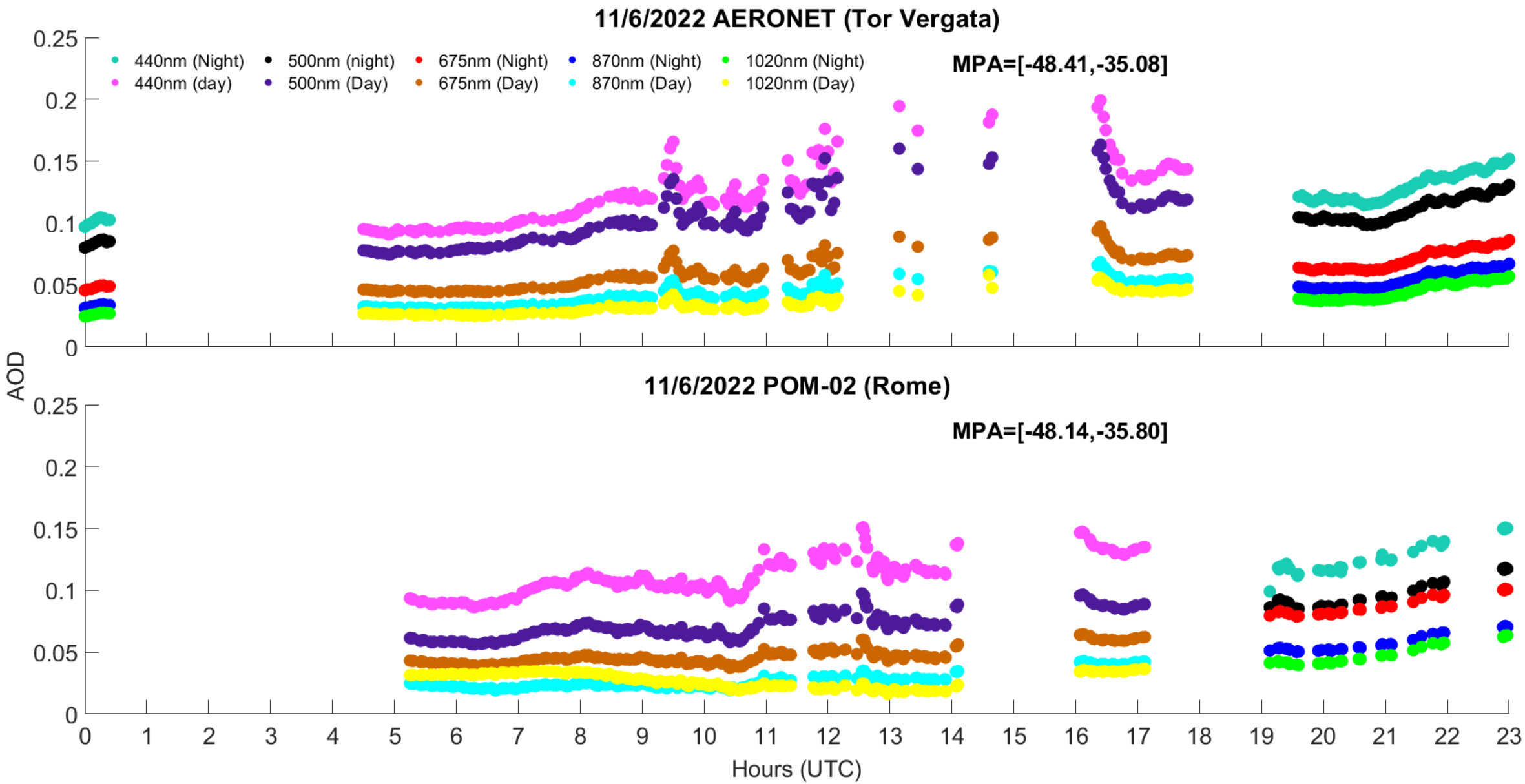
0.15
0.2
0.25
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23


11/6/2022 AERONET (Tor Vergata)
440nm (Night)
440nm (day)
500nm (night)
500nm (Day)
675nm (Night)
675nm (Day)
870nm (Night)
870nm (Day)
1020nm (Night)
1020nm (Day)
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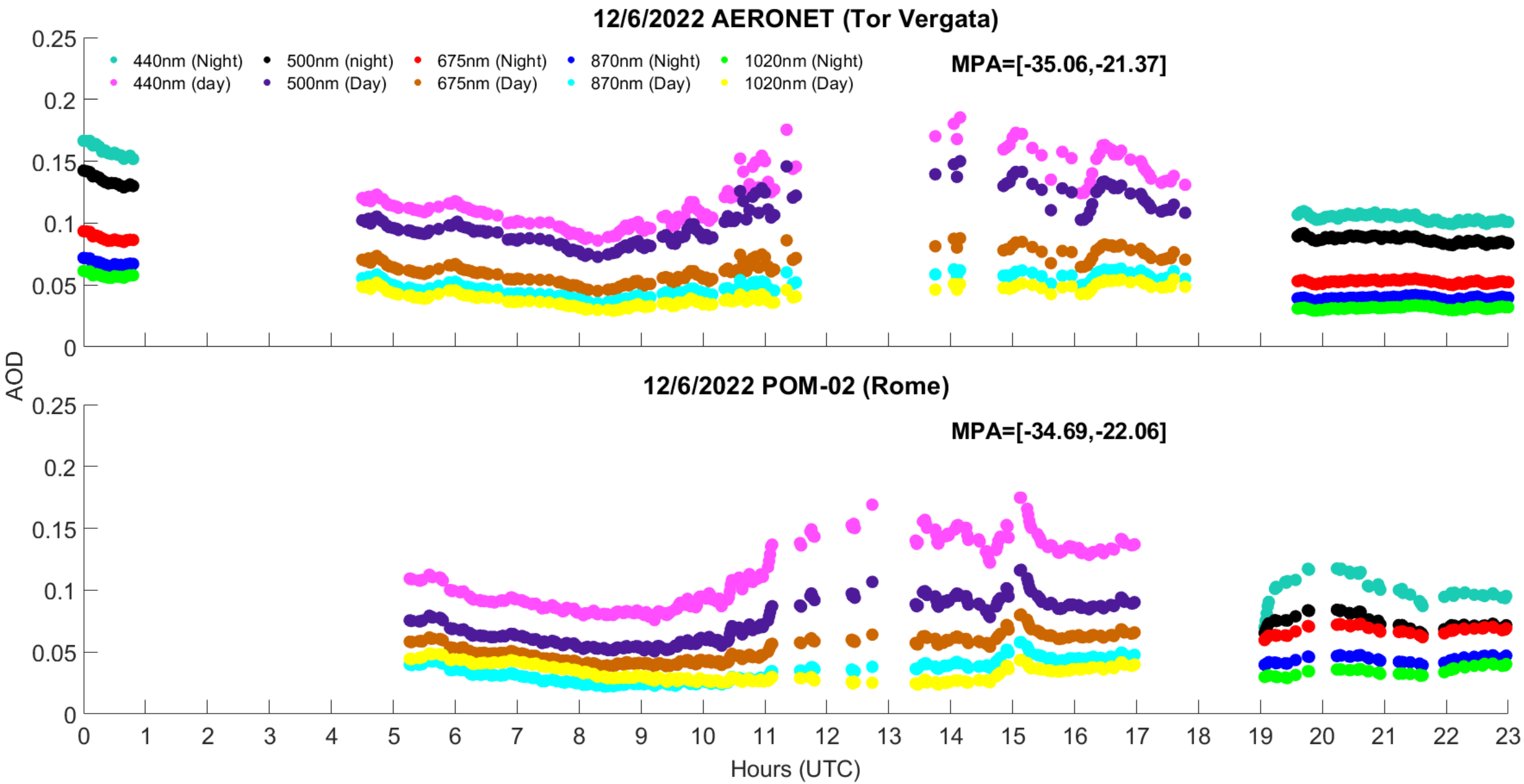
AOD
Hours (UTC)


12/6/2022 AERONET (Tor Vergata)
440nm (Night)
440nm (day)
500nm (night)
500nm (Day)
675nm (Night)
675nm (Day)
870nm (Night)
870nm (Day)
1020nm (Night)
1020nm (Day)
MPA=[-35.06,-21.37]
12/6/2022 POM-02 (Rome)
MPA=[-34.69,-22.06]
AOD
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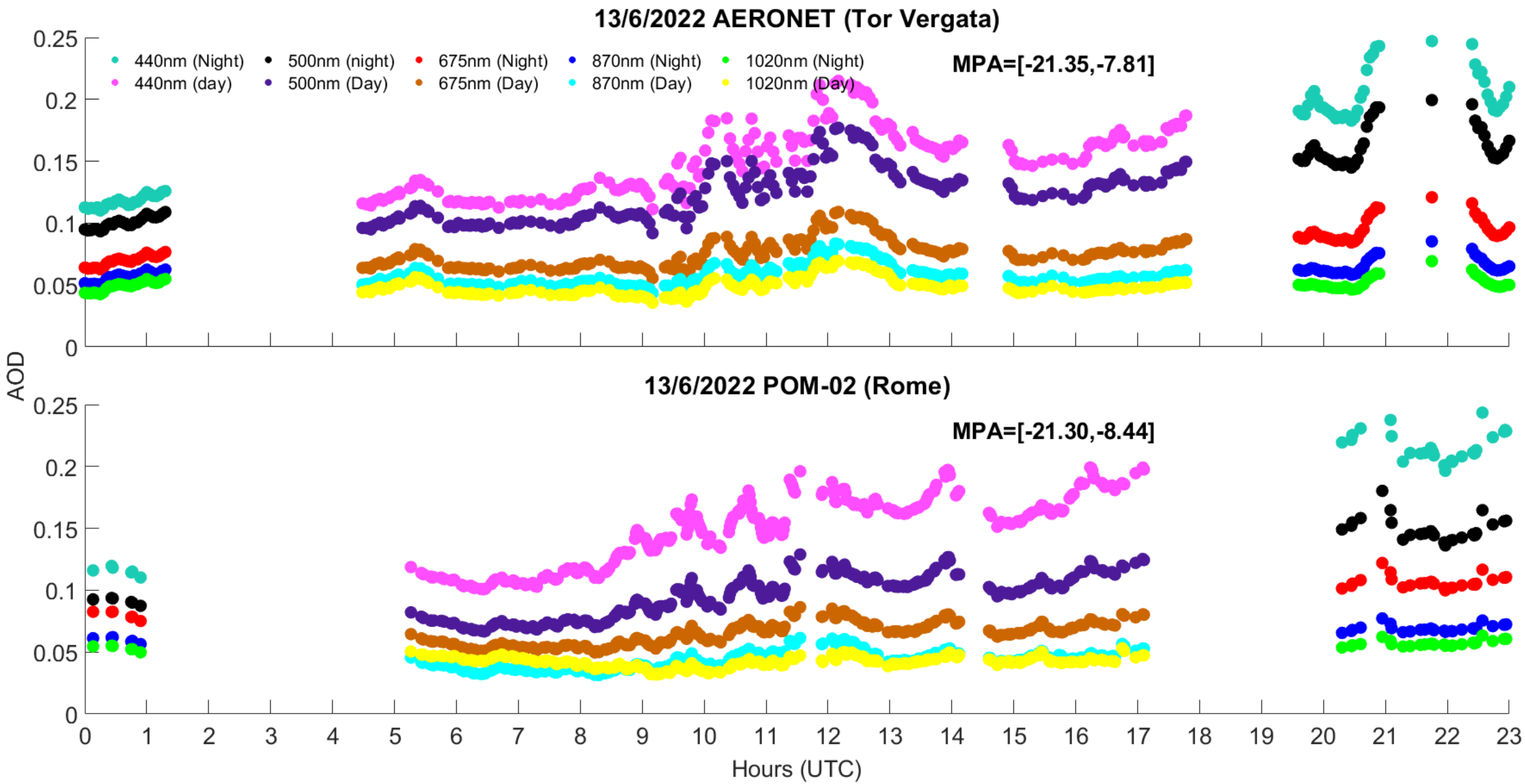
13/6/2022 AERONET (Tor Vergata)
440nm (Night)
440nm (day)
500nm (night)
500nm (Day)
675nm (Night)
675nm (Day)
870nm (Night)
870nm (Day)
1020nm (Night)
1020nm (Day)
MPA=[-21.35,-7.81]
13/6/2022 POM-02 (Rome)
MPA=[-21.30,-8.44]
AOD
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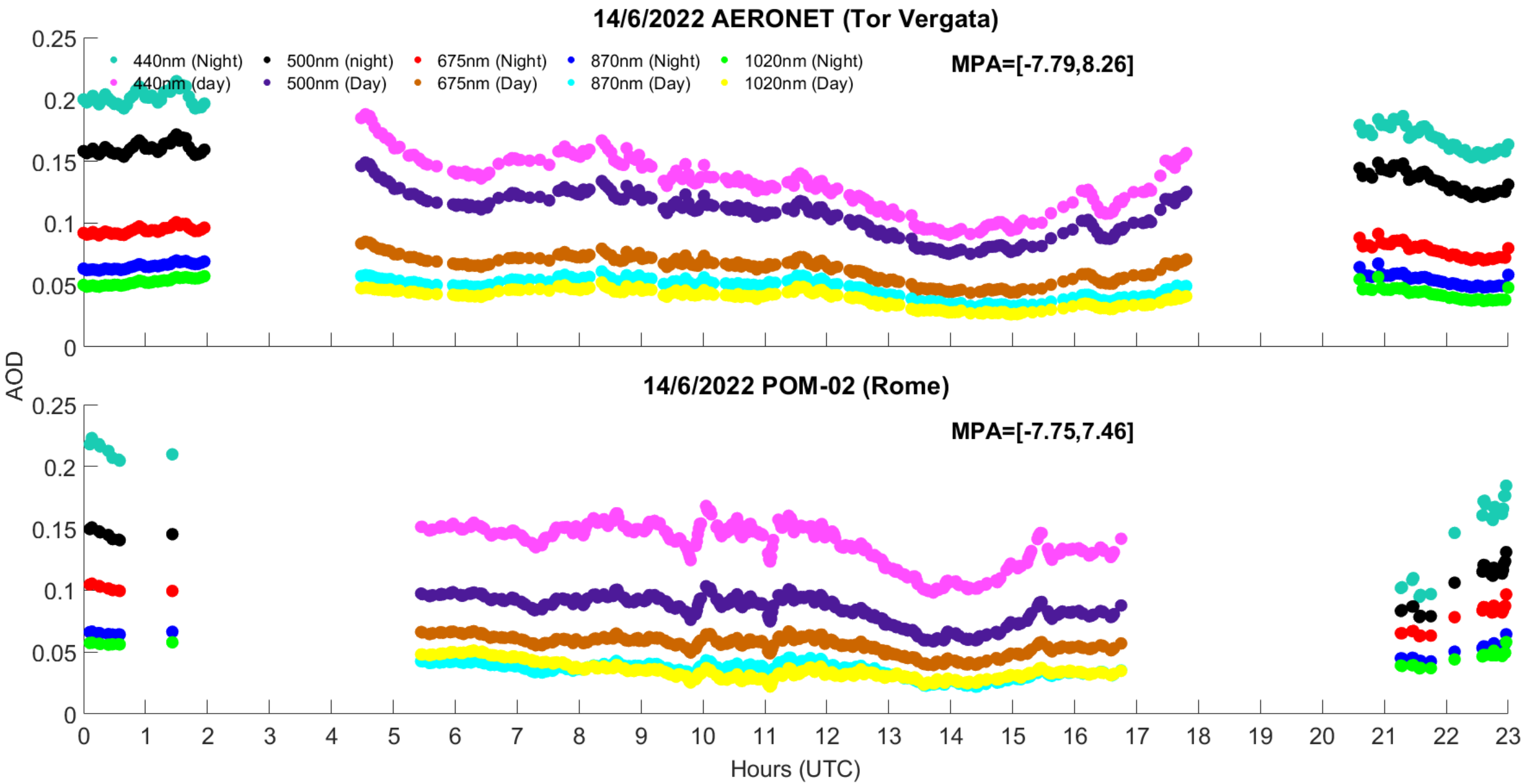
14/6/2022 AERONET (Tor Vergata)
440nm (Night)
440nm (day)
500nm (night)
500nm (Day)
675nm (Night)
675nm (Day)
870nm (Night)
870nm (Day)
1020nm (Night)
1020nm (Day)
MPA=[-7.79,8.26]
14/6/2022 POM-02 (Rome)
MPA=[-7.75,7.46]
AOD
Hours (UTC)
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0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

What to be done as SKYNET network

Upgrade solar calibration constant values every month if available

Check the cloud screening criteria

Confirm the validity of the used Ac and Bc coefficients: Izana ?

Try different reflectance models ?

The importance of simultaneous – coordinated measurements