World Meteorological Organization
Weather • Climate • Water

GOBIERNO DE ESPAÑA
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA
AEMet Agencia Estatal de Meteorología

WORLD METEOROLOGICAL ORGANIZATION
CIMO TECO 2018
Amsterdam, 8-11 October 2018

Last activities and results of the WMO-CIMO Testbed for Aerosols and Water Vapor Remote Sensing Instruments (Izaña, Spain)

E. Cuevas (ecuevasa@aemet.es), A. Barreto, R. Ramos, R. García, F. Almansa, A. J. Berjón and C. Guirado

Meteorological State Agency of Spain (AEMET)

Outline:

- Results of the first multi-instrument lunar photometric campaign was held at Izaña Observatory between June 1th and 17th 2017, including a side workshop on nocturnal aerosols measurement

- The new open-access "ROLO Implementation for Moon-photometry Observation" (RIMO) model development and comparison with USGS ROLO model

- Synergy photometer/lidar methodologies for retrieving vertical aerosol extinction including a two-layer approach using two sun-photometers located at two different levels

- Validation of AOD in the UV range using Brewer spectrophotometers in a pre-operational basis

- Validation of the ZEN-52 zenith radiometer for aerosols and water vapor determination using both Look-up Table and GRASP inversion

- Aerosols retrievals from spectral direct irradiance measurements with an EKO MS-711 spectroradiometer

- Educational and capacity building activities

1. The first multi-instrument lunar photometric campaign (Izaña, June 1-17, 2017)

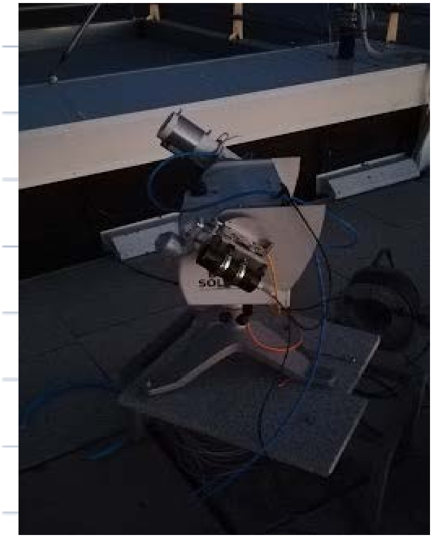
CHALLENGES IN MOON PHOTOMETRY

- Using the Moon as a calibration target for on-orbit sensors: the vicarious calibration and validation using the Moon as reference source is currently be viewed as a key technique to ensure an unprecedented accuracy for past, present and future Earth Observation (EO) missions

- Improve dynamic range and sensitivity of sensors to measure the low incoming signals of the Moon.

- Overcome the problem that arise from the variability of the reflected Sun irradiance with the Moon's cycle. This variability forces the use of a lunar extraterrestrial irradiance model for calibration (USGS/ROLO, uncertainty 5-10%).

PARTICIPANTS



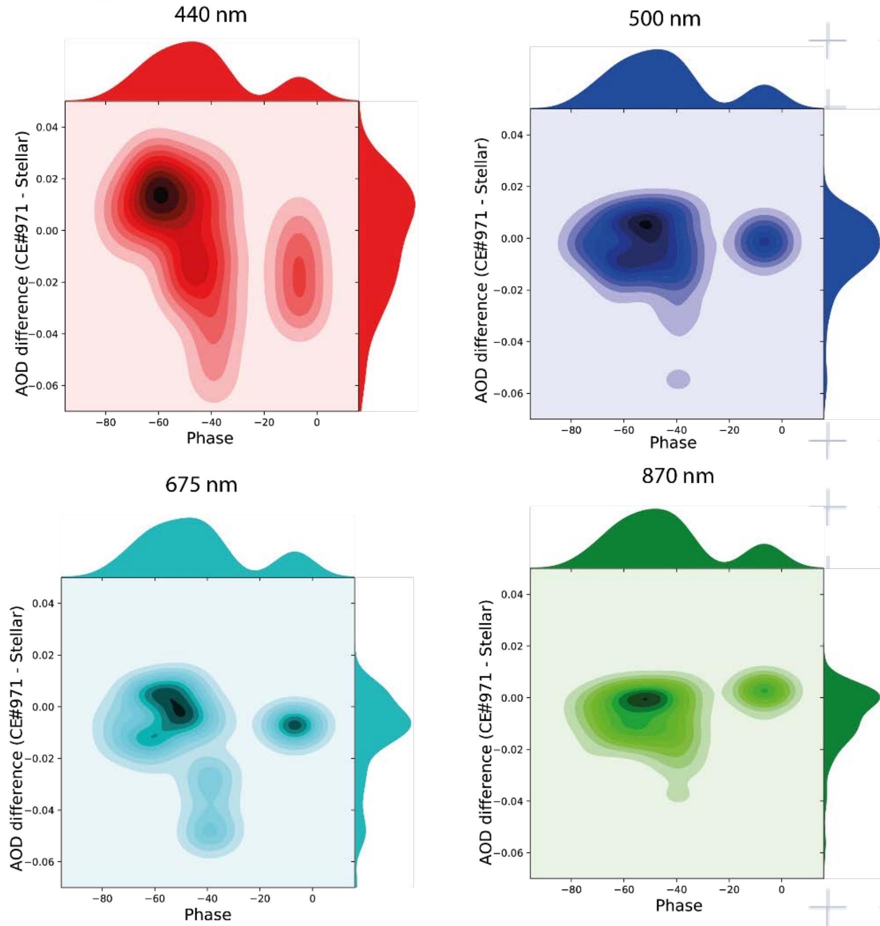
Instrument type	Institution
6 Triple Cimel (CE318-T)	IARC (Spain)
	2 LOA (France)
	MOL-RAO (Czech Republic)
	2 UVA (Spain)
LunarPFR	PMOD-WRC(Switzerland)
Stellar	UGR (Spain)

RESULTS

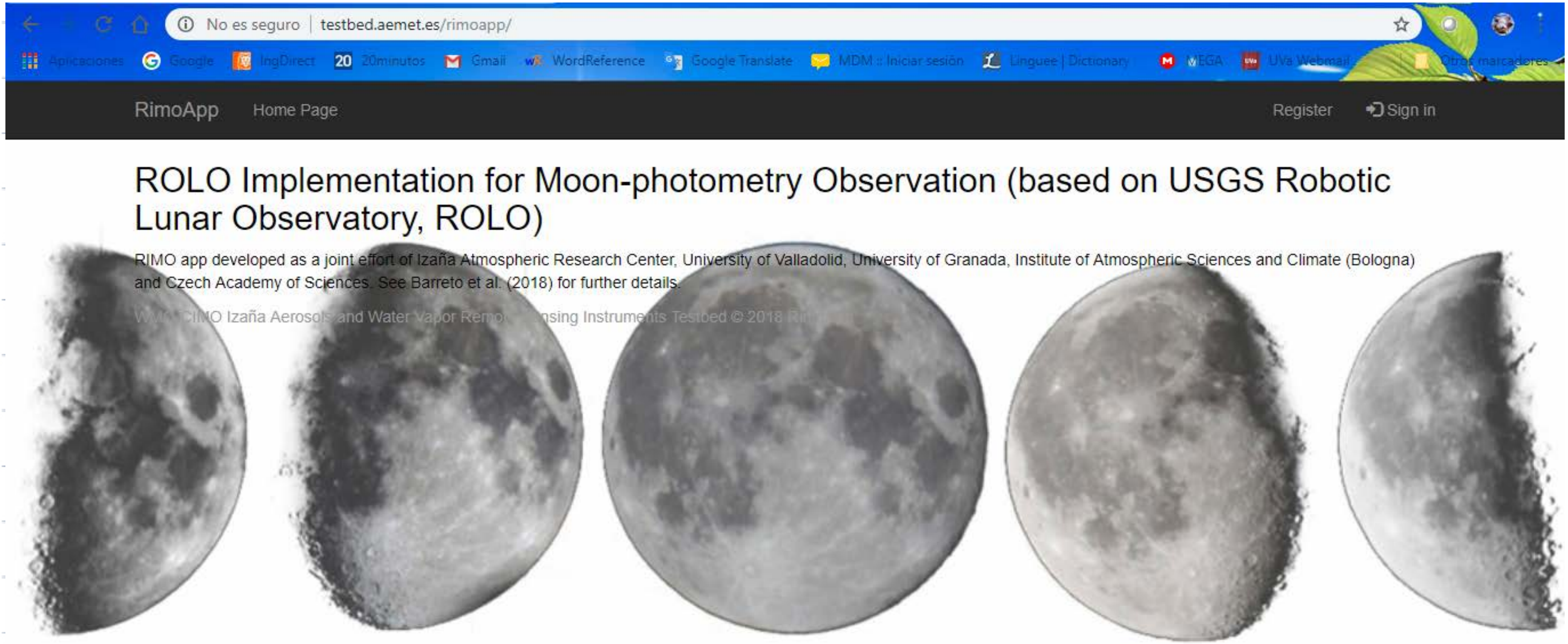
- The three types of photometers have consistent results, being the small differences observed between them within the expected AOD uncertainty of these photometric techniques.

- No evidence of significant differences with the Moon's phase angle when comparing raw signals and AOD of the photometers involved in this field campaign.

- Next publication: Barreto et al. (2018), Atmos. Environ., in revision.

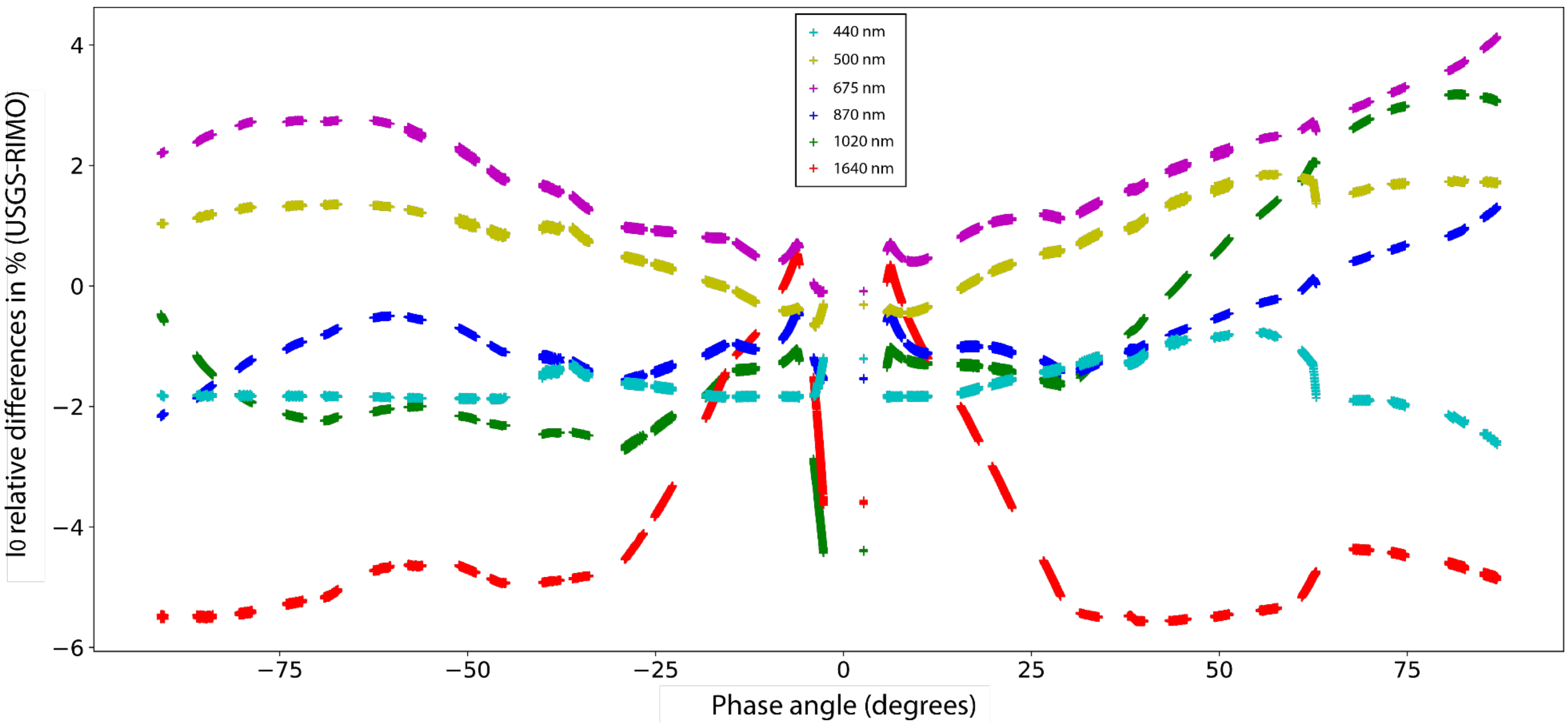


2. The new open-access "ROLO Implementation for Moon-photometry Observation" (RIMO) model development and comparison with USGS ROLO model



Joint effort of the Izaña Atmos. Res. Centre (Spain), University of Valladolid (Spain), University of Granada (Spain), Institute of Atmospheric Sciences and Climate (Bologna-Italy) and the Czech Academy of Sciences

Comparison analysis: RIMO vs ROLO



We conclude that the two models show similar performance during the Moon's cycle (Barreto et al., 2018; Atmos. Environ., in revision)

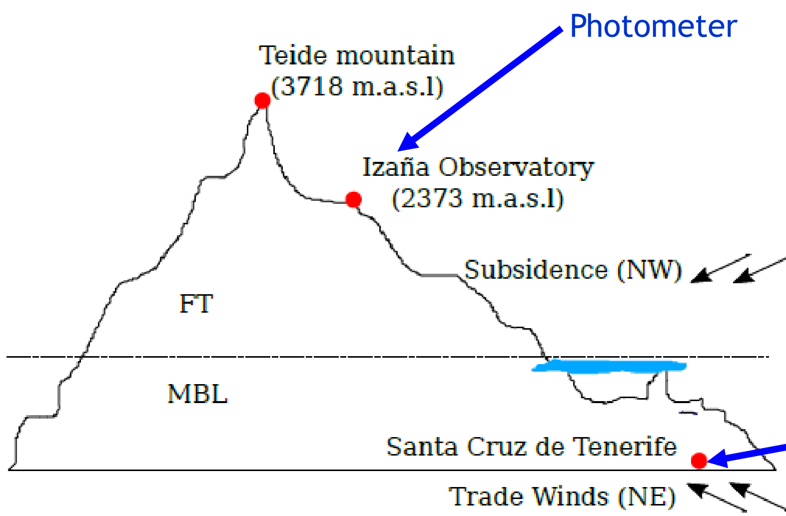
http://testbed.aemet.es/rimoapp/

3. Synergy photometer/lidar methodologies for retrieving vertical aerosol extinction including a two-layer approach using two sun-photometers located at two different levels

A preliminary two-layer approach has been developed to obtain more reliable vertical atmospheric extinction (α) using:

Micropulse lidar (MPL-3 Lidar) at Santa Cruz de Tenerife (SCO, 52 m a.s.l.)

AOD measurement at two sites at different heights in Tenerife: SCO and IZO (2373 m a.s.l.) stations.

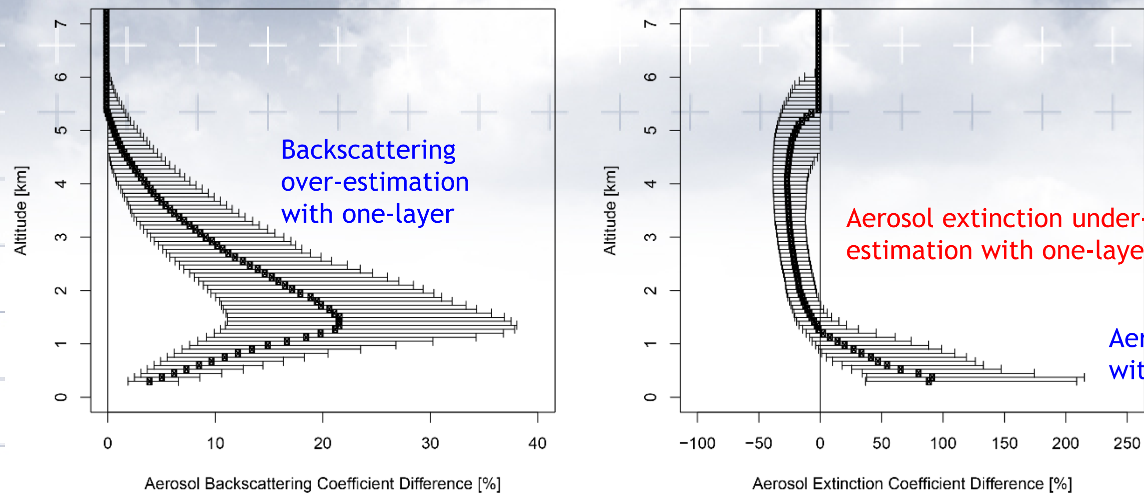


Photometer + MPL lidar

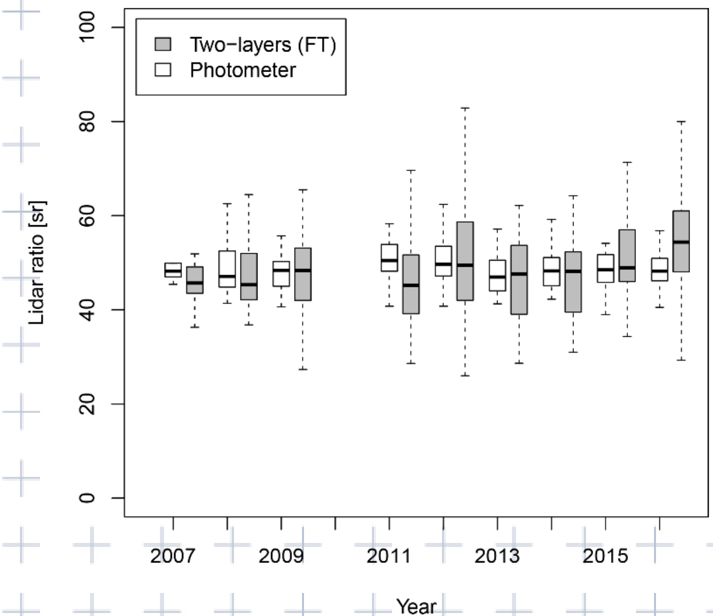
Comprehensive assessment of the <u>classical Fernald-Klett method</u>.

This method is generally used to retrieve information of vertical extinction profiles

Aerosol lidar ratio=
extinction to backscatter ratio ($S_{aer} = \sigma_{aer}/\beta_{aer}$)



Statistics of the differences on backscattering and extinction coefficients obtained by using One- and Two-layer methods. For each height, median difference, first and third quartile are shown (from **Berjón et al., ACP in preparation**).



Upper layer lidar ratio from Two-layer method (grey boxes) and from AERONET inversion with the sunphotometer data at IZO (white boxes) for each year between 2007 and 2016 (from **Berjón et al., ACP in preparation**).

Consistency of the lidar ratios retrieved in the upper layer by means of the Two-layer method, and independent lidar ratio from photometric measurements at IZO!!

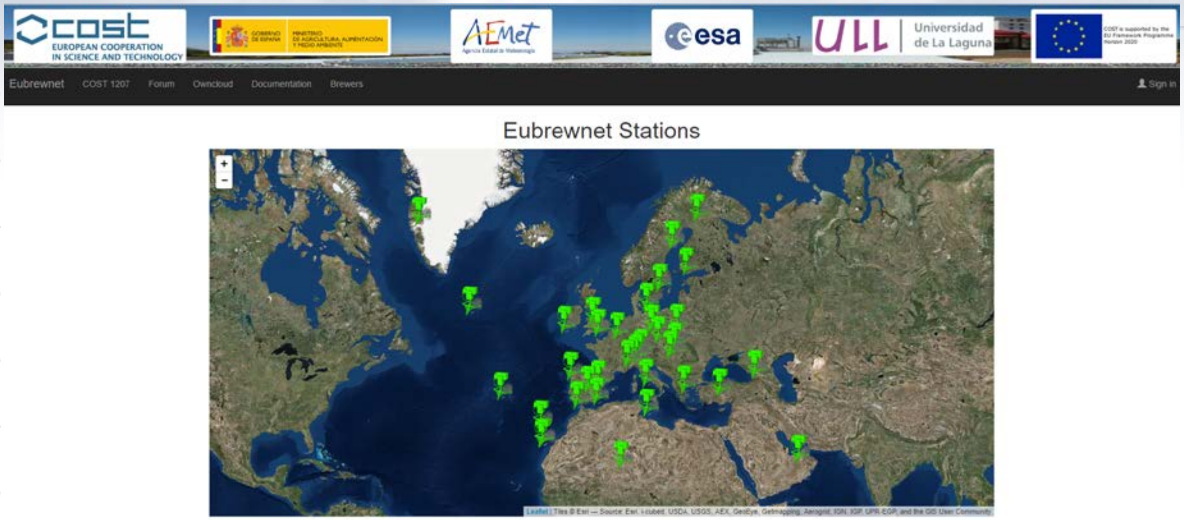
4. Validation of AOD in the UV range using Brewer spectrophotometers in a pre-operational basis

The effect of aerosols on solar UV radiation is important since it is linked with the impact of UV radiation on human health, atmospheric chemistry and biosphere

AERONET and GAW-PFR networks provide an extensive database of AOD in the UVA spectral range. However, only a few instruments are capable of performing AOD measurements in the UVB.

Brewer spectrophotometers, conceived for column ozone monitoring have already demonstrated their ability to measure AOD in the UVB spectral range
(López-Solano et al., 2018; ACP)

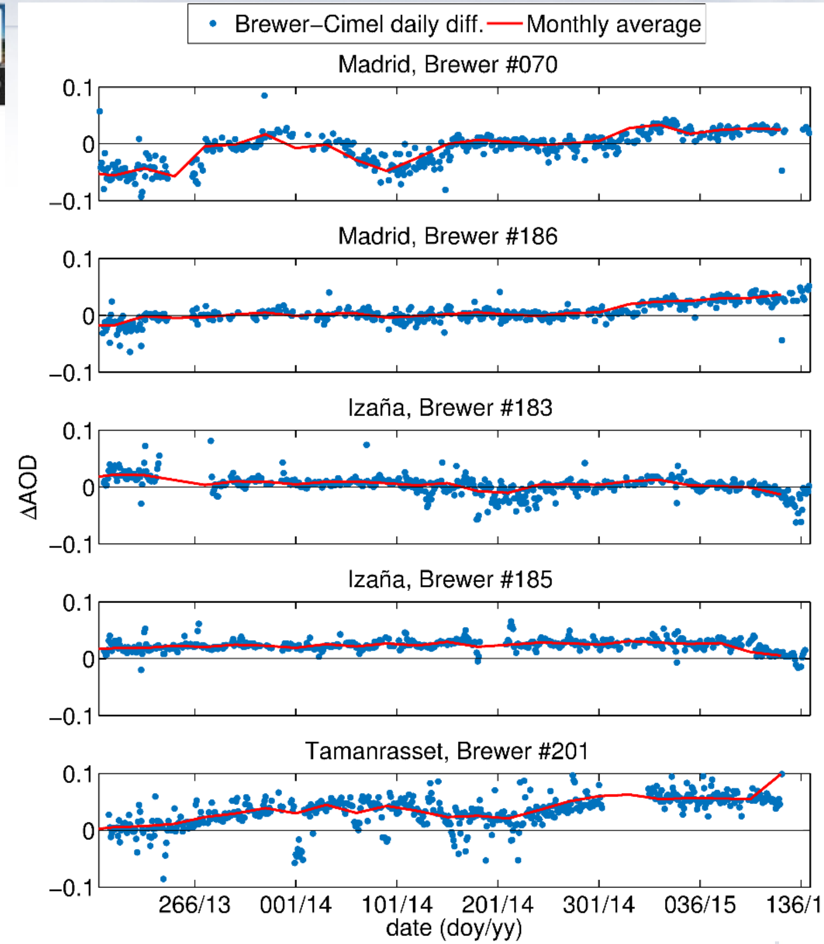
The UVB AOD product generated using a common data processing procedure has been developed and assessed within the European COST project EUBREWNET (European Brewer network, http://www.eubrewnet.org/cost1207) at the Regional Brewer Calibration Center for Europe (RBCCE, Izaña Atmospheric Research Center, AEMET), and as part of the activities carried out at the WMO-CIMO Testbed.



The precision, stability, and uncertainty of the Brewer AOD in the UVB range (300 to 320 nm).

This analysis includes comparisons with Cimel sun photometers and UV-PFR instruments

- ✓ Brewer AOD precision better than 0.01
- ✓ Uncertainty < 0.05
- ✓ Stability similar to that of the O3 measurements in the case of well-maintained instruments



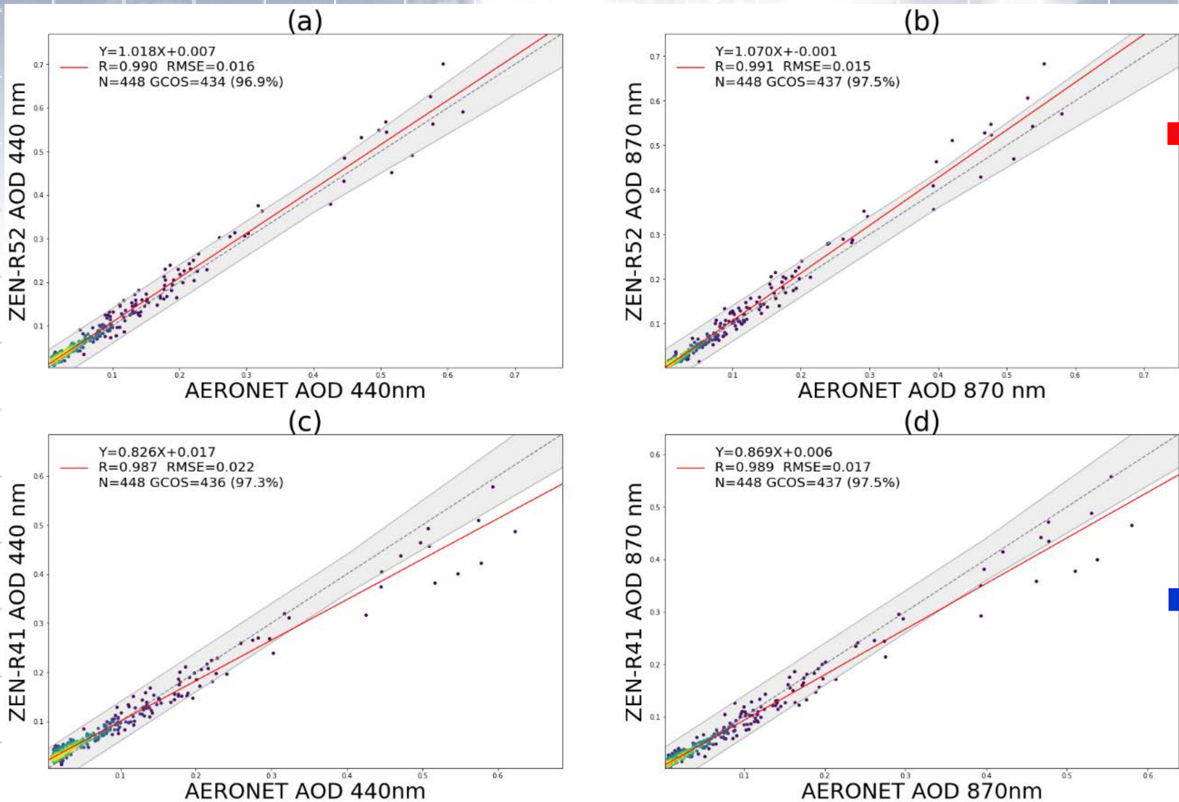
Brewer and Cimel AOD daily difference for the 2013-2015 period for different stations (from López-Solano et al., 2018; ACP).

5. Validation of the ZEN-52 zenith radiometer for aerosols and water vapor determination using both Look-up Table and GRASP inversion

The former ZEN-R41 system was conceived to expand dust aerosol monitoring from ground-based instrumentation in desert areas with a high degree of autonomy and robustness (Almansa et al., 2017; AMT).

The new ZEN-R52 is an improved and upgraded version of the ZEN-R41 prototype, with remarkable differences:

- reduced field of view
- increased signal to noise ratio
- better stray light rejection
- additional channel in 940 nm for precipitable water vapor (PWV) retrieval

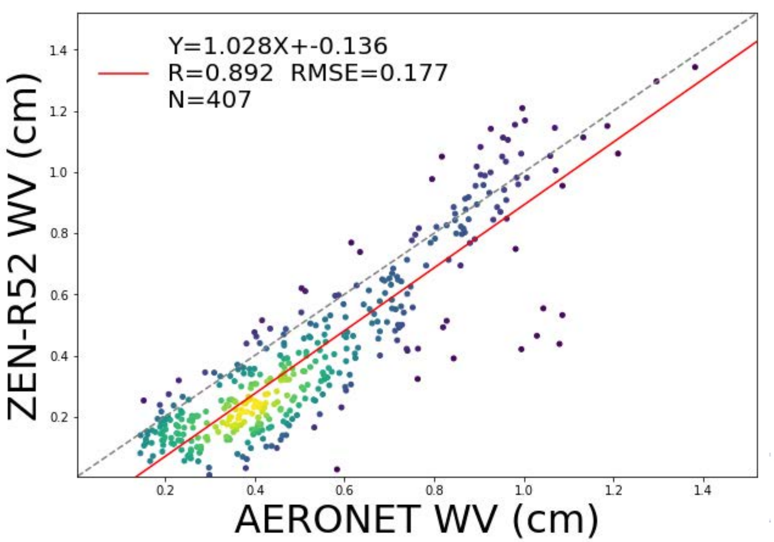


ZEN-R52

Scatterplot between AOD measured at 440 nm and 870 nm by the two ZEN systems and AERONET data: ZEN-R52 (upper panel) and ZEN-R41 (lower panel)

(from Almansa et al., AMT in preparation)

ZEN-R41



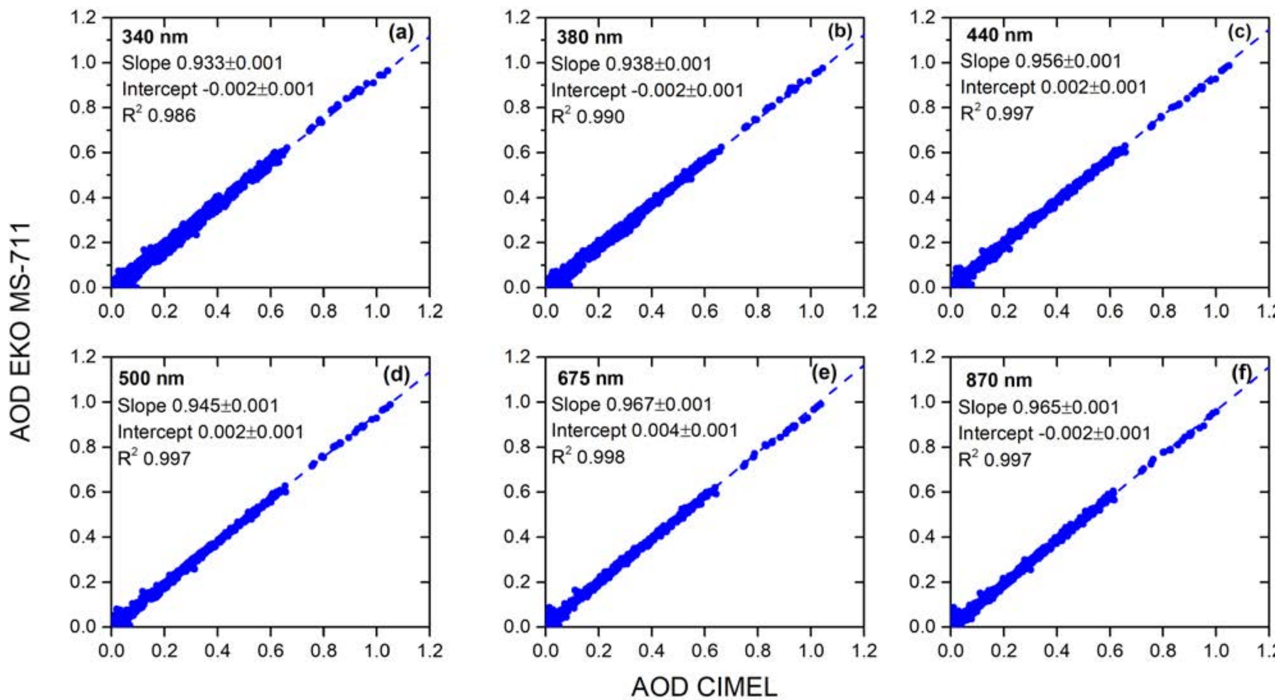
PWV comparison between AERONET and ZEN-R52 (from Almansa et al.; AMT in preparation)

6. Aerosols retrievals from spectral direct irradiance measurements with an EKO MS-711 spectroradiometer

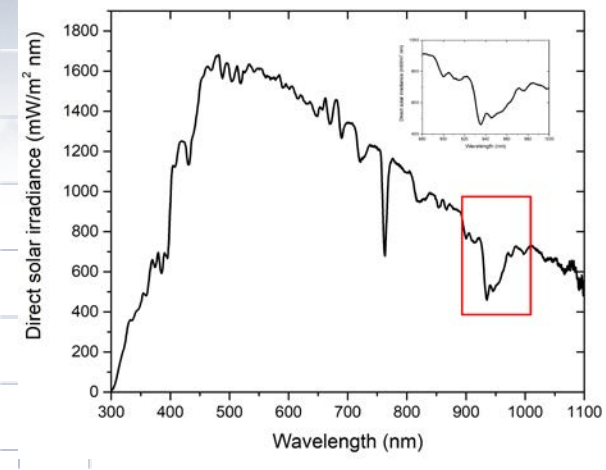
Wavelength range	300 to 1100 nm
Wavelength interval	0.3 - 0.5nm
Optical resolution FWHM	< 7nm
Wavelength accuracy	+/- 0.2 nm
Cosine Response (Zenith: 0~80°)	< 5%
Temp. dependency (-10°C to 50°C)	< 2 %
Exposure time	10 msec - 5 sec

$$ln(I(\lambda)) = ln\ I_o(\lambda) - \tau\, m$$

$$AOD\ (\lambda) = (\ ln\ (I_o(\lambda)/I(\lambda)\ ) - \sum(\tau_i\ (\lambda) m_i)\ )\ /\ m_a$$



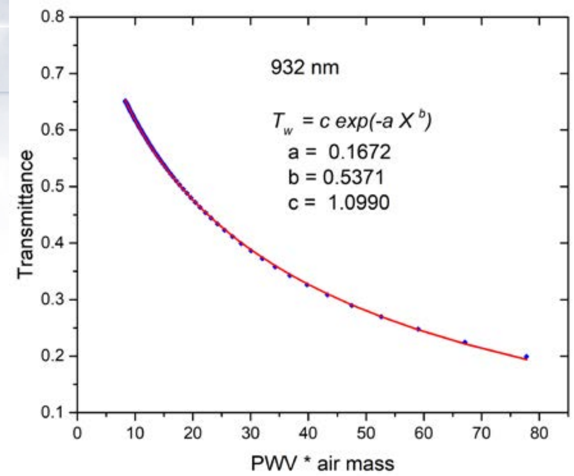
N: 5536; March - December 2017



Experimental dependency between PWV and transmittance:

$$PWV = \frac{1}{m_w}\left(\frac{\ln\left(T_w/c\right)}{-a}\right)^{1/b}$$

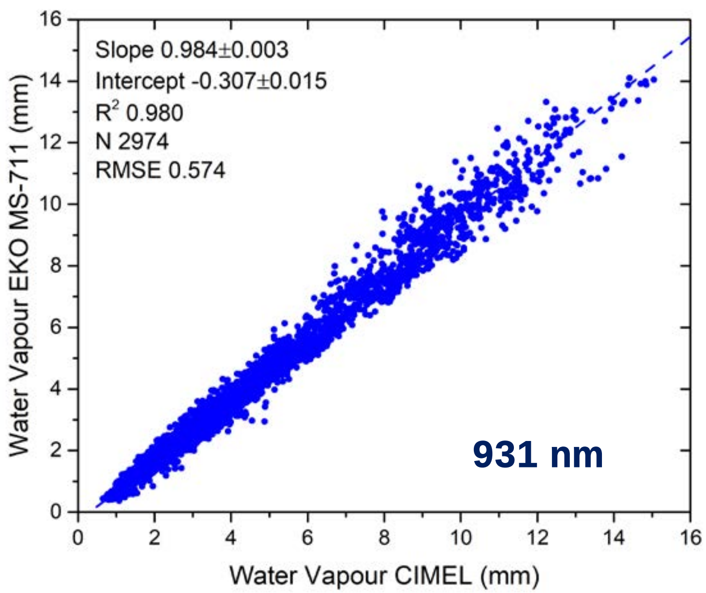
m_w= water vapor optical mass
T_w= Water vapor transmittance



LibRadtran model considering line by line computations

Comparison between PWV from EKO MS-711 spectral direct irradiance and PWV from CIMEL-AERONET

	a	b	c
931 nm	0.1532	0.5215	1.110
932 nm	0.1672	0.5371	1.099
936 nm	0.1821	0.5591	1.072
937 nm	0.1927	0.5401	1.097
939 nm	0.1928	0.5151	1.141
941 nm	0.1658	0.5329	1.115
945 nm	0.1783	0.5274	1.098



	EKO/CIMEL (mm)			
	RMSE	Bias	Std	R
931 nm	0.685	0.398	0.557	0.983
932 nm	1.022	0.851	0.567	0.985
936 nm	2.199	1.853	1.185	0.981
937 nm	2.235	1.891	1.191	0.986
939 nm	2.506	2.184	1.229	0.739
941 nm	2.159	1.884	1.055	0.979
945 nm	2.420	2.105	1.194	0.979

March - December 2017

7. Educational and capacity building activities

The Ministry of Education and Universities of the Canary Islands Government and AEMET-IARC have initiated a joint project to raise awareness of the problem of airborne dust and its impacts on health and the environment throughout the educational community in April 2018.

This project, called “Calima”, includes the pioneering use of remote sensing instruments, and specifically low cost sun photometers (Calitoo-Tenum handheld sunphotometers) designed and produced for the GLOBE (Global Learning and Observation to Benefit the Environment) project.

The Canary Islands Government has purchased 10 Calitoo photometers installed in 8 islands which have been calibrated and checked at the Izaña Observatory (AEMET). A user-friendly interface based on mobile phones has been developed at IARC so that students can send AOD data to a centralized database of the CALIMA project with their own means.

Thank you for your attention

ecuevasa@aemet.es
http://izana.aemet.es

Agencia Estatal de Meteorología