

## **RIMA-AERONET network: long-term monitoring of aerosol properties**

### **Red RIMA-AERONET: medida a largo plazo de propiedades de aerosoles**

C. Toledano<sup>(\*,S)</sup>, V. E. Cachorro<sup>(S)</sup>, A. Berjón<sup>(S)</sup>, A. M. de Frutos<sup>(S)</sup>, D. Fuertes, R. González,  
B. Torres, R. Rodrigo, Y. Bennouna, L. Martín, C. Guirado

Atmospheric Optics Group (GOA), University of Valladolid (UVA), Prado de la Magdalena s/n, 47071, Valladolid, Spain.

(\*) Email: toledano@goa.uva.es

S: miembro de SEDOPTICA / SEDOPTICA member

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#### **ABSTRACT:**

RIMA (Red Ibérica de Medida fotométrica de Aerosoles) is a scientific network for the long-term monitoring of columnar aerosol properties based on sun-photometer measurements. RIMA is federated to AERONET (AEROSOL ROBOTIC NETWORK), a NASA program in collaboration with the University of Lille (France). According to the AERONET aims, the scientific objectives of RIMA involve the characterization of the aerosol for climate studies, the validation of satellite products and the synergism with other measurements and techniques. RIMA follows all AERONET protocols (calibration, measurements, data policy, etc.) and its sites and data are available through the AERONET web site. The key task of calibration and the network management are carried out by the Group of Atmospheric Optics of the University of Valladolid (GOA-UVA) and master instruments are calibrated at the high-mountain facility CIAI (Izaña Atmospheric Research Center, AEMET) in collaboration with PHOTONS and CIAI-AEMET. Large support is obtained from the AERONET (NASA) and PHOTONS (Univ. of Lille). The calibration facility is in operation since 2006. A software named Caelis (www.caelis.uva.es) was recently developed by GOA as a service to the RIMA community with the aim to facilitate the network management and the control of the site instruments and measurements. This tool relies on a powerful relational data base which represents a great potential for the scientific work as well.

**Keywords:** Aerosols, Sunphotometry, AERONET, Calibration.

#### **RESUMEN:**

La red RIMA (Red Ibérica de Medida fotométrica de Aerosoles) tiene como objetivo la medida a largo plazo de las propiedades ópticas en columna de los aerosoles atmosféricos. RIMA está federada a la red AERONET (AEROSOL ROBOTIC NETWORK), que es un programa de la NASA en colaboración con la Universidad de Lille (Francia). De acuerdo con los fines de AERONET, los objetivos científicos de RIMA tienen que ver con la caracterización de los aerosoles para estudios climáticos, la validación de medidas de satélite y la sinergia con otro tipo de medidas e instrumentación. RIMA sigue todos los protocolos de AERONET (calibraciones, programa de medidas, política de datos, etc.) y toda la información sobre las estaciones, así como los datos, son accesibles a través de la página web de AERONET. La tarea clave de calibración y dirección operativa de la red es llevada a cabo por el Grupo de Óptica Atmosférica de la Universidad de Valladolid (GOA-UVA), y la calibración de los master que precisa una estación remota a gran altitud, se realiza en Centro de Investigaciones Atmosféricas de Izaña (CIAI) en colaboración con PHOTONS y CIAI-AEMET. Además se cuenta con el apoyo de AERONET (NASA) y PHOTONS (Universidad de Lille). La estación de calibración de RIMA está operativa desde 2006. La aplicación CAELIS, recientemente desarrollada por el GOA-UVA, tiene como objetivo proporcionar un servicio a la comunidad de usuarios de RIMA, para facilitar la organización de la red y mejorar el control sobre los instrumentos y datos. Este software se ha construido sobre una base de datos relacional y es además una potente herramienta para la investigación

**Palabras clave:** Aerosoles, Fotometría Solar, AERONET, Calibración.

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**1. Introduction**

The ground-based monitoring of aerosol properties with remote sensing instruments is accomplished by various networks, like the Aerosol Robotic Network (AERONET), Global Atmosphere Watch (GAW), European Aerosol Lidar Network (EARLINET) and many others. We will focus here in the AERONET, which is a NASA program for long-term observation of aerosol properties, focused on providing data for aerosol characterization at a global scale, validation of satellite products and the synergism with other types of aerosol measurements.

The AERONET program [1] started in 1998 and nowadays collects data in more than 300 sites throughout the globe. AERONET is a federation of networks established by NASA and PHOTONS (University of Lille). The great success of the network relies on the standardization of instruments, processing, calibration and distribution, as well as the public access to the database. After 10 years of project, there are more than 1000 publications in which AERONET data are used. However the expansion of the network raised problems regarding the calibration capability. After the AERONET workshop in 2004, a third calibration center belonging to the Spanish sub-network RIMA (Iberian Network for Aerosol Measurements) was considered necessary, to reduce the burden

of the calibration facilities in NASA and PHOTONS.

The data processing and archive are centralized in NASA. Currently the version 2 algorithm for direct Sun and inversions is operational. The next version 3 is scheduled for 2012. The data are archived in the 3 well known levels 1.0 (raw data), 1.5 (cloud-screened) and 2.0 (cloud-screened and quality-assured).

The Iberian network for Sun photometer aerosol measurements is a scientific network that was created in 2004 with the aim of promoting the collaboration among the partner institutions, all of them devoted to the measurement and analysis of the columnar atmospheric aerosol properties. It is fully integrated in AERONET and currently includes 22 sites and 30 instruments. Most of the sites are located in Spain and Portugal, but RIMA is also in charge of sites in Germany, Finland, Norway and Cuba.

The aim of this paper is to describe the RIMA network and the calibration facility, development and future plans for the network.

**2. The RIMA network**

RIMA started operations as part of AERONET in 2006, after a joint calibration of all new instruments. The list of initial sites and



Fig. 1: Map of RIMA sites in Spain and Portugal in May 2011.

responsible institutions is given in Table I. The spatial coverage over the Iberian Peninsula, see Fig. 1, allows excellent monitoring of long-range transported aerosols, for instance the frequent desert dust outbreaks [2], and also extraordinary events like the arrival of volcanic ash from the Eyjafjallajökull volcano in Iceland [3]. Furthermore, RIMA sites are very appropriate for satellite validation over different environments: coastal, urban, Mediterranean, rural, etc.[4].

The RIMA calibration facility started operations in 2006. The calibration and the network management are carried out by the Group of Atmospheric Optics of the University of Valladolid (GOA-UVa) and master instruments are calibrated at the high-mountain facility CIAI

(Izaña Atmospheric Research Center, AEMET) in collaboration with PHOTONS and CIAI-AEMET. Large support is obtained from AERONET and PHOTONS. Daily every site sends the data to a server at the University of Valladolid, where the files are screened of basic parameters (instrument number, instrument location, file completeness, etc.) and sent to NASA for processing.

After the initial calibration in 2006, the usual 1-year operation and calibration has been carried out, according to the AERONET protocols. To reach level 2.0, the instrument must be calibrated before and after the deployment period and the data must fulfill a set of criteria (for details see the AERONET website [5]). The assessment for level 2.0 is performed at NASA.

In the last years RIMA has increased the calibration activity assuming sites around Europe that were calibrated by NASA or PHOTONS in the past. These are shown in Table I. In 2011-2012 5 more sites belonging to AEMET will be added to the network (Palma de Mallorca, Madrid, Zaragoza, Coruña and Murcia). This will fill the spatial gaps and will provide the Iberian Peninsula with full spatial coverage that will allow validation of satellite sensors, aerosol models, etc at a regional scale.

TABLE I

List of RIMA-AERONET sites and responsible institutions as for May 2011. UVA: Univ. of Valladolid; ARR: Andoya Rocket Range; NILU: Norwegian Institute for Air Research; UB: Univ. of Barcelona; UV: Univ. of Valencia; UEX: Univ. of Extremadura; INTA: Spanish Aerospace Agency; UGR: Univ. of Granada; CIAI-AEMET: Izaña Atmospheric Research Center- Spanish Meteorological Agency; ULL: Univ. of La Laguna; UEV: Univ. of Evora; INM: Cuban Meteorological Institute; FMI: Finnish Meteorological Institute; UHU: Univ. of Huelva; MIM-LMU: Meteorological Institute, Univ. of Munich; PSA-DLR: Plataforma Solar de Almería - German Aerospace Center.

(a) Initial sites	Country	Responsible Institution	(b) Sites after 2006	Country	Responsible Institution
Andenes	Norway	UVA, ARR, NILU	Birkenes	Norway	NILU
Autilla	Spain	UVA	Cabo da Roca	Portugal	UEV
Barcelona*	Spain	UB	Camagüey	Cuba	UVA, INM
Burjassot	Spain	UV	Evora	Portugal	UEV
Cáceres	Spain	UEX	Helsinki	Finland	FMI
El Arenosillo*	Spain	UVA, INTA	Huelva	Spain	UVA, UHU
Granada	Spain	UGR	Hyytiala	Finland	FMI
Izaña	Spain	CIAI-AEMET	Kuopio	Finland	FMI
La Laguna	Spain	ULL	Montsec	Spain	UB
Málaga	Spain	UGR	Munich University	Germany	MIM-LMU
Palencia	Spain	UVA	PSA-DLR	Spain	DLR

\*Discontinued 2010

### 3. Calibration facility

The RIMA calibration facility consists of an intercalibration platform, located at the little village Autilla del Pino (Palencia), and a calibration laboratory with optical and electronic equipment for instrument calibration and maintenance at Valladolid University. The master instruments (used for the calibration of field instruments) are calibrated at Izaña Observatory (2360 m a.s.l.), managed by AEMET, which is the master calibration platform for RIMA and PHOTONS.

#### 3.1. Intercalibration site: Autilla

The intercalibration site Autilla (41°N, 4°W) is located 45 km north of Valladolid in a plateau elevated 873 m a.s.l. The absence of aerosol sources, favourable weather, completely free horizon and the moderate elevation are very appropriate for calibration of the direct sun channels, which is carried out by comparison of the field instrument direct sun signals with a master instrument, previously calibrated at Izaña.

An example of observations collected at Autilla is shown in Fig. 2. These are level 1.0 (unscreened) and show the low cloud frequency and clean atmosphere at the site. Up to 16 days where suitable for calibration in that month. Requirements for intercalibration are AOD (440 nm) stable and below 0.2, full air mass range (~1 to 7) and enough number of cloud-free data points, especially around noon. In winter some long cloudy or foggy periods may occur at Autilla, as well as moderate turbidity during the summer due to desert dust or other transported aerosols (European pollution plumes, biomass

burning aerosols), but in general instruments do not wait longer than 2 weeks until sufficient data are collected for intercalibration. More than 140 intercalibration days are found each year.

The platform has capability for 9 photometers. Typically 2 masters are installed (to check stability), therefore up to 7 field instruments can be calibrated simultaneously. The use of 2 masters is justified to check stability and detect any shift in master calibration, that would trigger the arrival of fresh-calibrated masters from Izaña.

#### 3.2. Laboratory facility at Valladolid

The calibration laboratory at Valladolid University is equipped with a 2-lamp 8" integrating sphere (Sphere Optics), which is used for the radiance calibration of the sky channels.

The sphere is calibrated every 3 months by an AERONET travelling master that rotates throughout the entire network (NASA, PHOTONS; RIMA). This master instrument is calibrated in the Goddard Calibration Facility with the NASA reference spheres.

All instruments are routinely checked and maintained between the post and the pre-field calibrations: replacement of filters, upgrades, robot cleaning, etc. Therefore the entire calibration process is: intercalibration at Autilla, sphere calibration in the laboratory, cleaning and maintenance, new sphere calibration in the laboratory and new calibration at Autilla. It takes 4-8 weeks depending on the weather and the appearance of instrumental problems.

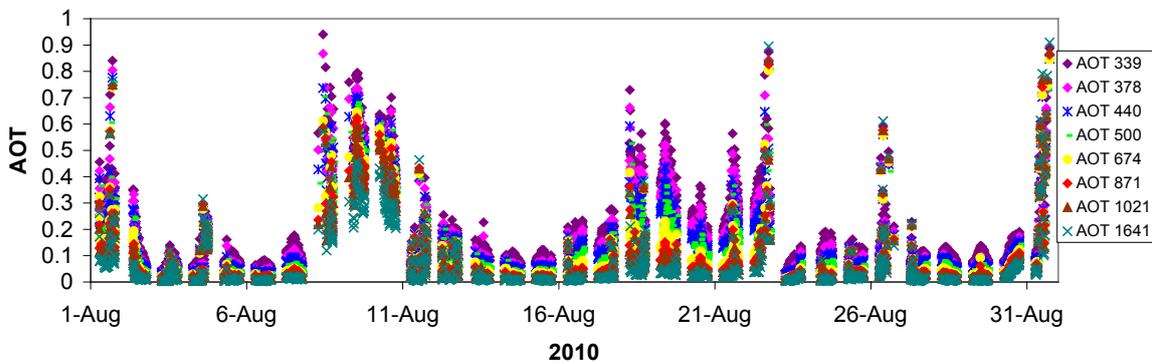


Fig. 2: Aerosol optical thickness (level 1.0) at Autilla during August 2010.

#### 4. The CÆLIS software tool

CÆLIS computing platform is developed to provide management of the RIMA network and control on the data. This software can be divided into three main elements: 1) A database that stores in an orderly manner, both the acquired data and processed results. 2) A system which provides the necessary mechanisms to manipulate the information in the database. 3) All the information generated by the system is offered to the users through a web interface. This is [www.caelis.uva.es](http://www.caelis.uva.es). Instrument and site descriptions are available, as well as several resources for site managers.

CÆLIS software is recently created and still evolving. The most mature functionalities of the system refer to the above operational objectives, but the work proposed for the future is to improve their capabilities to perform research tasks. The aim is to use all the infrastructure already assembled and by creating new modules provide the scientific community of generated products. These modules, connected to the rest of the system, could easily generate new real-time information visible through the web interface.

As an example, a real-time alarm system is provided to the site managers, in order to reduce the time needed to solve problems with the field instruments. This is expected to improve the amount of level 2.0 data.

#### 5. Conclusions

The RIMA calibration facility is operational since 2006. It is fully integrated in AERONET, following all protocols (instruments, calibration, processing, data distribution), as a federated network. It is in charge of 20 sites located mainly in Europe, although the number of sites is expected to increase the next years. Within the European project ACTRIS (Aerosol, Clouds, and Trace Gases Research Infrastructure Network), the calibration platform AEORNET-EUROPE, composed by University of Lille (PHOTONS) and the University of Valladolid (RIMA) and Izaña Observatory, will provide calibration to a set of project partners, helping expand the network. This project is a first step toward a stable financial support to AERONET-EUROPE, that is necessary for the long-term support of the calibration facilities needed to assure long-term monitoring of the aerosol properties in Europe.

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