Intercomparison of spanish advanced lidars in the framework of EARLINET

M. Sicard[a], M. N. Md Reba, F. Rocadenbosch, E. Gregorio[b], D. Kumar, S. Tomàs, A. Comerón
Dept. of Signal Theory and Communications, Remote Sensing Lab. (RSLAB)
Universitat Politènica de Catalunya (UPC)
Barcelona, Spain

F. Molero, M. Pujadas
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT)
Madrid, Spain

J. L. Guerrero-Rascado, L. Alados-Arboledas
Dept. of Applied Physiscs, Facultad de Ciencias
Universidad de Granada
Granada, Spain

R. Pedros, J. A. Martínez
Dept. of Thermodynamics, Facultat de Fisica
Universitat de Valencia
Valencia, Spain

***Abstract*—To extend and reinforce the action of the EARLINET-ASOS project, a nucleus of Spanish advanced lidars was created. Four systems were intercompared satisfactorily in terms of backscatter coefficients at two elastic wavelengths.**

Keywords: aerosols; lidar network; instrument intercomparison

I. INTRODUCTION

Active instruments such as lidars provide detailed information on the aerosol space distribution throughout the observation line of sight at day or nighttime. Satellite-based lidars (GLAS, on board of ICESAT (2003), CALIOP, on board of CALIPSO (2006)) offer a global cover but with revisit times on the order of ten days. Coordinated terrestrial lidar networks offer simultaneously the temporal and vertical high resolution of each individual instruments and the space sampling of an extensive geographic zone.

EARLINET (European aerosol research lidar network to establish an aerosol climatology) [1] was created in May 2000 within a project from the Fifth Framework Programme (FP) of the European Union (EU). The network started with 19 stations and is currently totalizing 27. Since March 2006 it is endorsed by the coordinated action EARLINET-ASOS from the Sixth FP of the EU. The main objective of EARLINET-ASOS is to improve the EARLINET infrastructure resulting in a better spatial and temporal coverage of the observations, continuous quality control for the complete observation system, and fast availability of standardized data products.

The lidars from EARLINET present a great variety of characteristics [2] and one of the specific objectives of EARLINET-ASOS is to optimize instruments and define advanced lidars able to operate unattended and to acquire enough data so as to retrieve range-resolved aerosol optical and microphysical parameters. To concentrate their efforts on this specific objective, the spanish lidar community created a spanish advanced lidar network. The first goal of this network is to perform an intercomparison of instruments and check the results against EARLINET quality control tolerances.

II. THE SPANISH ADVANCED LIDAR NETWORK

The Spanish advanced lidar network is an initiative from the three spanish groups belonging to EARLINET-ASOS aims to promote the use of lidar instruments and data among the spanish scientific community. The mains goals of the network are:

- Extend and reinforce the actions of EARLINET-ASOS;
- Form a nucleus for stimulating the Spanish lidar community;
- Promote the participation of new groups for improving the spatial cover of aerosol vertical measurements on the spanish territory (including Portugal).

A total of 8 research centers or universities are participating:

- Universidad Politècnica de Catalunya (Barcelona, BAR);
- Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (Madrid, MAD);
- Universidad de Granada (Granada, GRA);
- Universidad de La Laguna (La Laguna, LLA);
- Instituto Nacional de Técnica Aerospacial (Santa Cruz de Tenerife, SCT);
- Universidad de Valencia (Valencia, VAL);
- Universidad de Murcia (Murcia, MUR);
- Universidad Politécnica de Cartagena (Cartagena, CAR).

The main characteristics of the instruments involved in the network are summarized in Table 1 and their geographical repartition is shown in Fig. 1. So far, only the intercomparison of the BAR, MAD, GRA and VAL systems was performed.

[a] Corresponding author: msicard@tsc.upc.edu
[b] Now with Dept. of Electrical Engineering, Universitat Politècnica de Catalunya (UPC), Barcelona, Spain

TABLE I. CHARACTERISTICS OF THE LIDARS INVOLVED IN THE SPANISH ADVANCED LIDAR NETWORK

	Lidar stations							
λ (nm) / E (mJ)	***BAR***	***MAD***	***GRA***	***LLA***	***SCT***	***VAL***	***MUR***	***CAR***
Lidar model	laboratory	laboratory	Raymetrics LR321	Eridan LSA-2c	SES Inc. MPL-3	CIMEL Electronique CAML CE370-2	laboratory	Elight UV11
Elastic IR 1064	**X / 160**		**X / 110**	X / 100			X / 1000	
Elastic VIS 532	**X / 160**	**X / 100**	**p/s[a] / 65**	X / 50	X[b] / 0.01	**X / 0.004**	X / 500	
Elastic UV 355			X / 60				X / 250	
Elastic UV 266							X / 110	
Elastic UV 390-399							X	X
Elastic UV 255-290							X	X
Raman VIS 607	**X**	**X**					X	
Raman UV 387			X				X	
Raman UV 407 (WV)			X				X	
PRF (Hz)	10	20	10	10	2500	4600	10	20
Scanning capability	X	X		X			X	X
System transportable	X	X	X		X	X		X
Overlap (km)	0.25	~0.4	0.3	~0.3	1.5		0.2-2	~0.3
Max range (km)	50	15	60-90	10	60	5	50	5

a. Detection of both P- and S-polarized wavelength.

b. at 523 nm.

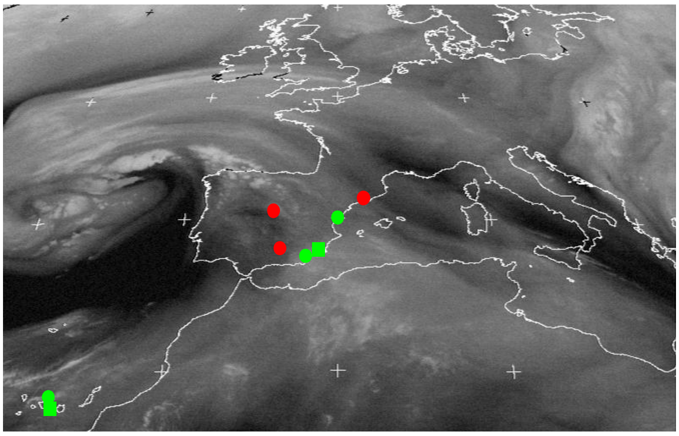

Figure 1. Geografical distribution of lidars on the Spanish territory. Circles and squares indicate transportable and untransportable systems, respectively. The red color indicates the systems belonging to EARLINET-ASOS.

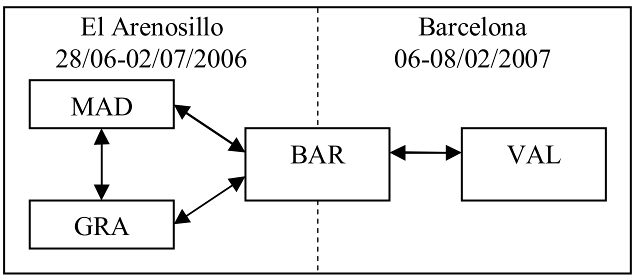

Figure 2. Diagram of intercomparison experiments.

III. INTERCOMPARISON FIELD CAMPAIGNS

One campaign took place in el Arenosillo (37.10N, 6.70W) in the south of Spain during 28/06-02/07/2006 and another one in Barcelona (41.39N, 2.11E) during 06-08/02/2007. Fig. 2 shows the diagram of the intercomparison campaigns.

A. *Objectives of the intercomparisons*

The common goals of both field campaigns are:

- During the campaign, compare the range-square-corrected profiles from different instruments pointing at the same atmospheric target to evidence differences in the pre-processing;
- After the campaign, compare quantitatively retrieved backscatter and extinction coefficients, and qualitatively the same coefficients by comparing with other types of instruments (ground and column).

B. *Methodology*

Diurnal cycle measurements were performed from 0800 to 2000UTC at the maximum number of elastic wavelengths possible with a 1-min. time resolution. The deliverable profiles had to be integrated over 10 min. All the groups with Raman channels also performed nighttime measurements starting at 2130UTC with a 1-min. time resolution. The deliverable profiles were integrated over 120 min.

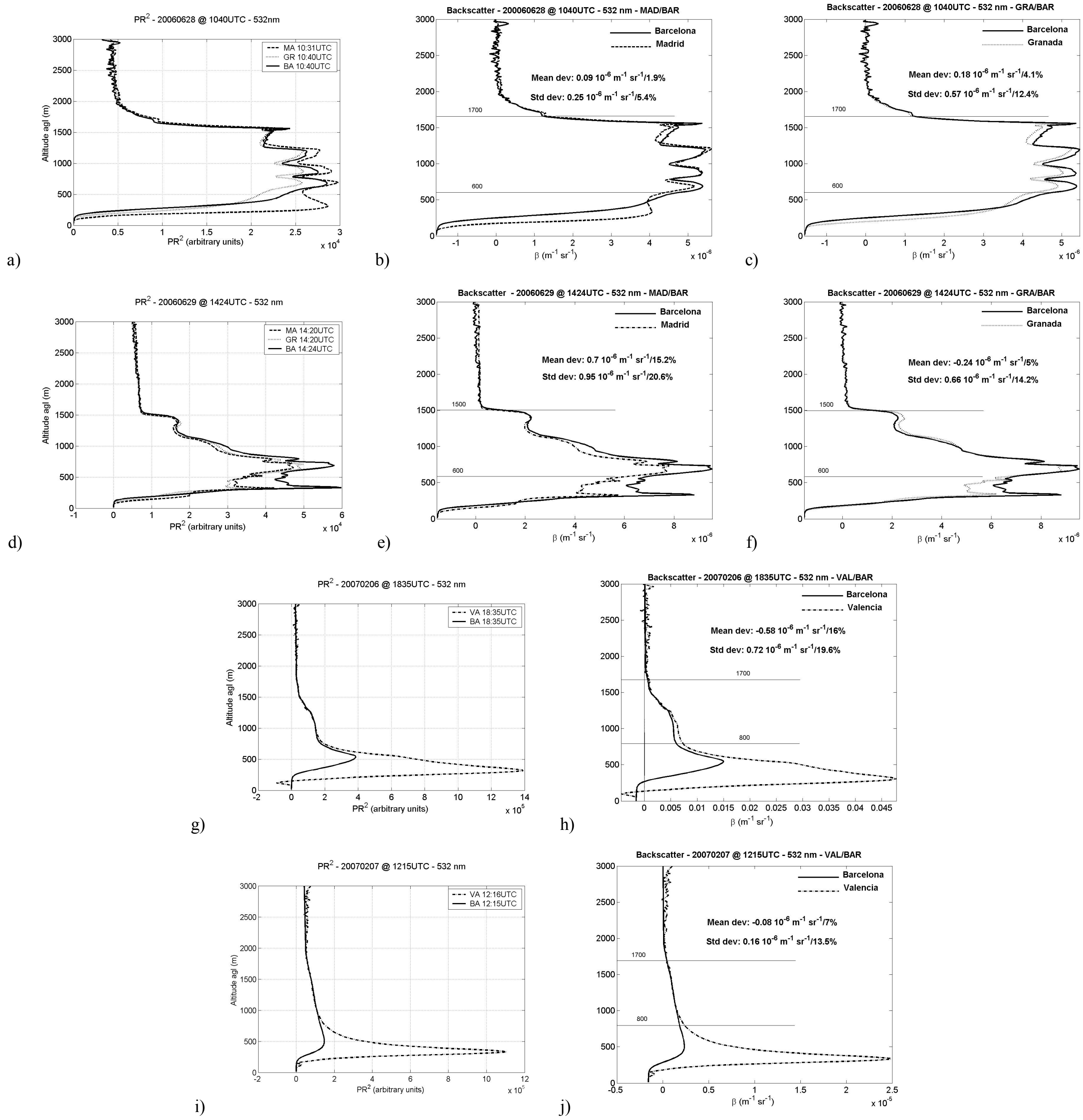

Figure 3. Intercomparison of aerosol backscatter profiles at 532 nm between BAR, MAD, GRA and VAL systems.

IV. Results and Discussion of the Problems Found

A total of three wavelengths (1064, 532 and 607 nm) were compared between the four stations (see bolt crosses in Table 1). So far only the backscatter coefficient profiles retrieved with the Klett-Fernald-Sasano method [3][4][5] were compared.

Fig. 3 shows the intercomparison of the four lidars at 532 nm. The intercomparison of the GRA system with BAR at 1064 nm is shown in Fig. 4. The cases presented were chosen for the relatively high extension of the aerosol plume they present, however it was impossible to fulfil the minimum height interval condition fixed by EARLINET (2000 m). The results show the importance of the pre-processing optimization for all groups, and more particularly:

- the knowledge of the detectors' dynamical margins,
- the stabilization of the electronic chain,
- the overlap factor correction,

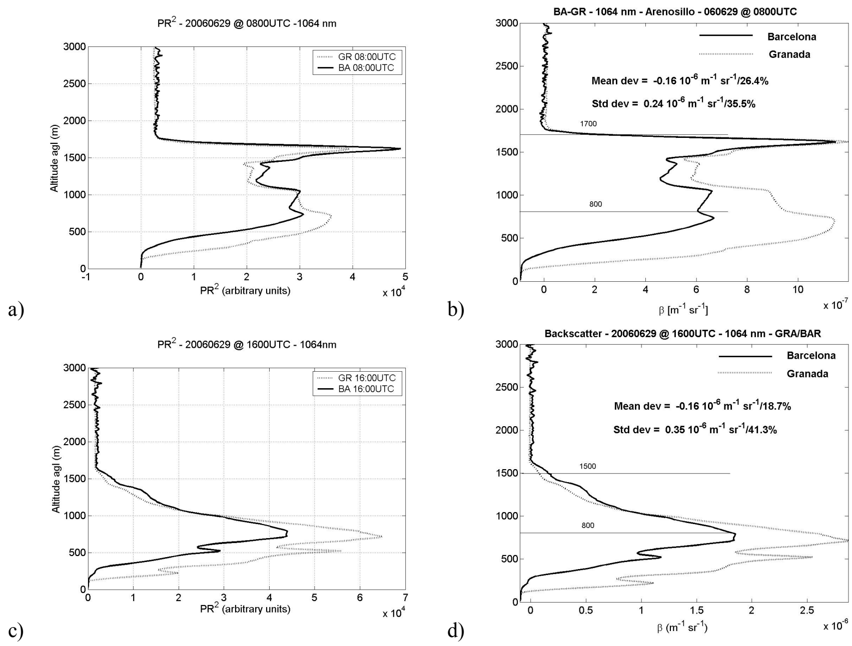

Figure 4. Intercomparison of aerosol backscatter profiles at 1064 nm between BAR and GRA systems.

TABLE II. MEAN AND STANDARD DEVIATION OF THE INTERCOMPARISON BETWEEN BAR, MAD, GRA AND VAL SYSTEMS

	Height Range (m)	*Mean dev. (10^{-6} $m^{-1}sr^{-1}$)*	*Std dev. (10^{-6} $m^{-1}sr^{-1}$)*
BAR-MAD, 532 nm			
20060628 @ 1040UTC	600-1700	0.09/1.9%	0.25/5.4%
20060629 @ 1424UTC	600-1700	0.7/15.2%	0.95/20.6%
BAR-GRA, 532 nm			
20060628 @ 1040UTC	600-1700	0.18/4.1%	0.57/12.4%
20060629 @ 1424UTC	600-1700	-0.24/5%	0.66/14.2%
BAR-VAL, 532 nm			
20070206 @ 1835UTC	800-1700	-0.58/16%	0.72/19.6%
20070207 @ 1215UTC	800-1700	-0.08/7%	0.16/13.5%
BAR-GRA, 1064 nm			
20060629 @ 0800UTC	800-1700	-0.16/26.4%	0.24/35.5%
20060629 @ 1600UTC	800-1700	-0.16/18.7%	0.35/41.3%

- the correct background calculation,
- the appropriate use of smoothing techniques.

They also showed that under the same atmospheric conditions the agreement between two systems at 532 nm is better than at 1064 nm. Table 1 summarizes the mean and standard deviation of all 8 cases shown in Fig. 3 and 4. All of them are within EARLINET maxima (20 % for the Mean dev. and 25 % for the Std. dev. at 532 nm and 30 % for both deviations at 1064 nm) except the Std. dev. at 1064 nm. The very low value of the optical thickness (< 0.05) could be an explanation of the disagreement.

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