Inter-comparison of lidar methods for obtaining planetary boundary-layer height from a July 2012 monitoring campaign over the Iberian Peninsula in the framework of EARLINET

UPC Raman lidar

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1. Introduction

- Planetary boundary-layer (**PBL**) is defined as the height of the inversion level separating the free troposphere from the BL [4]
- PBL height is important in applications from climate studies to air quality modeling
- Lidar with high spatial (< 30 m) and temporal (< 5 min) resolutions can be employed to monitor PBL height using aerosol as tracers
- Several techniques are tested in this work:
  - derivative methods: gradient method (**GM**) and inflection-point method (**IPM**)
  - covariance methods: wavelet covariance transform (**WCT**) with unique dilations

2. European Aerosol Research Lidar Network (EARLINET)

EARLINET (Figure 1) is the 1st aerosol lidar network, established May 2000 to provide an aerosol climatology over Europe [1]. More info at **www.earlinet.org**

Figure 1. Map of the 4 EARLINET stations in the Iberian Peninsula (**IP**).

3. Data and Methodology

3.1 Lidar and radiosondes

- 4 elastic-Raman multi-wavelength stations from EARLINET (Table 1)
  - 72-hr campaign: 9th - 12th July, 2012
  - 532 nm range-corrected signals (RSCS)
- Radiosoundings from Barcelona, Granada, and Madrid used for "true" PBL height detection with Richardson bulk number approach

EARLINET	Lidar stations in the Iberian Peninsula			
	Barcelona	**Granada**	**Madrid**	**Evora**
Latitude/longitude Elevation	41.389 N, 2.112 E 115 m	37.164 N, 3.605 W 680 m	40.456 N, 3.726 W 669 m	38.568 N, 7.912 W 293 m
Lidar model	laboratory	Raymetrics LR321	laboratory	PollyXT
Number of vertical points	8,190	16,000	4,096	2,048
Pulse repetition frequency	20 Hz	20 Hz	20 Hz	20 Hz
Overlap height	~ 500 m	~ 500 m	~ 400 m	~ 450 m
Maximum range	30.7125 km	60-90 km	30 km	60 km
Vertical resolution (Raw)	3.75 m	7.5 m	7.5 m	30 m
Distance from radiosounding	720 m	12 m	13.28 km	N/A
Line-of-sight	52°	0°	0°	5°

Table 1. Characteristics of EARLINET lidars in the IP.

3.2 Methods: PBL height from lidar

GM is height where minimum of first derivative of RSCS ➡

$$h_{GM} = min\left[\frac{\partial RSCS}{\partial r}\right] \quad (1)$$

IPM is height where minimum of second derivative of RSCS ➡

$$h_{IPM} = min\left[\frac{\partial^2 RSCS}{\partial r^2}\right] \quad (2)$$

WCT is height where maximum of co-variance of wavelet ➡

$$H\left(\frac{z-b}{a}\right) = \begin{cases} 1 & for \quad b - a/2 \leq z \leq b \\ -1 & for \quad b < z \leq b + a/2 \\ 0 & \quad otherwise \end{cases} \quad (3)$$

$$W_f(a,b) = a^{-1}\int_{z_b}^{z_t} B(z)h\left(\frac{z-b}{a}\right)dz \quad (4)$$

4. Results

- Evora, Granada, and Madrid exhibit daily evolution of PBL height with average daytime maximum between 1.0 - 1.5 km
- Best correlation (R^2=0.88) using WCT at Barcelona when compared to 12z radiosoundings
- All lidar methods have issues when multiple layers are present (Figure 2) due to clouds (2a), tropospheric aerosol layers (2b), or low signal-to-noise ratio (2c)
- Nocturnal boundary-layer (NBL) is difficult to retrieve with lidar due to overlap effects

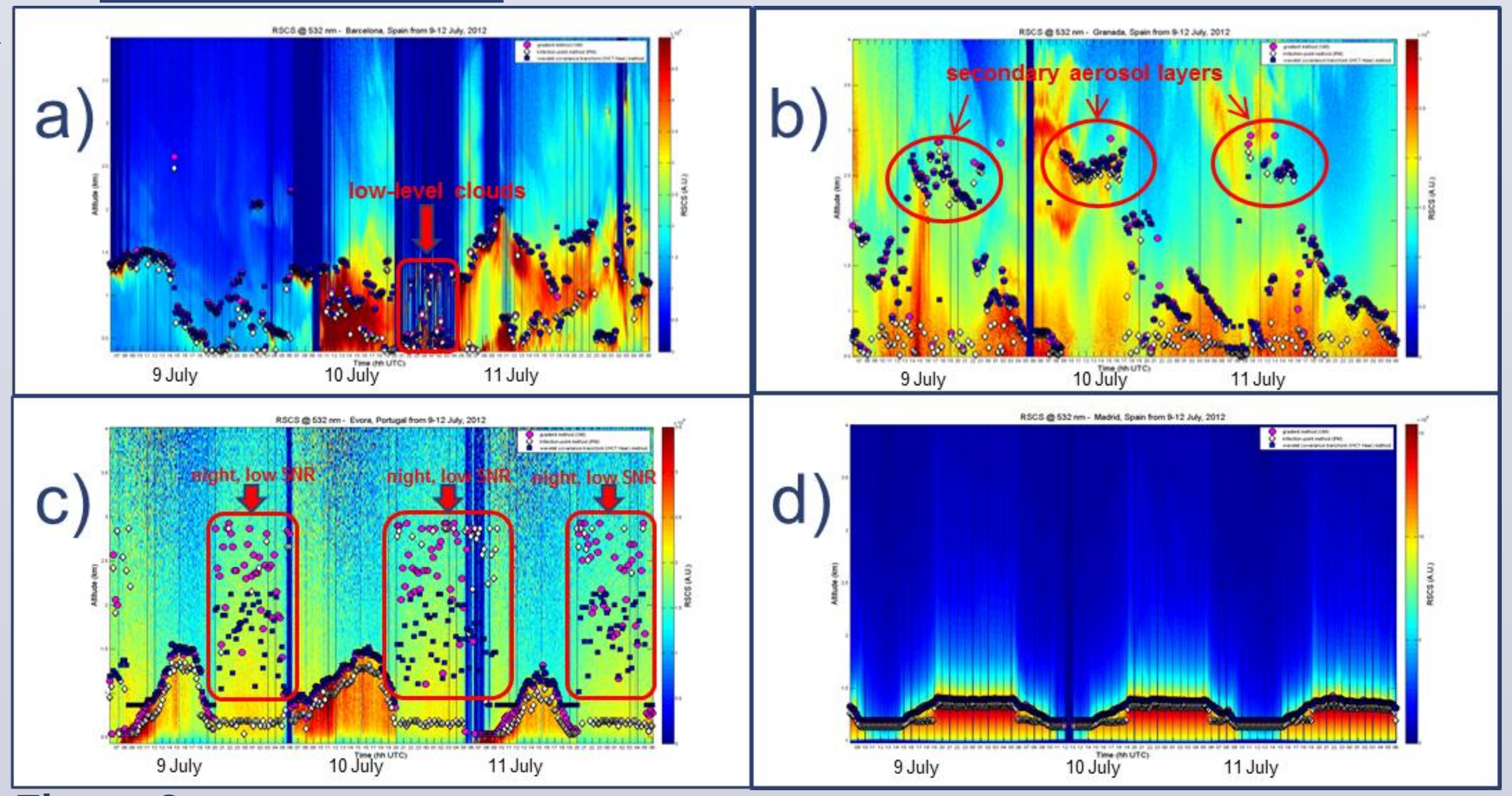

Figure 2. RSCS time-height series at 532 nm for a) Barcelona, b) Granada, c) Evora, and d) Madrid with 15-minute average PBL heights overlaid.

5. Conclusions

- Lidar proves to be a modern tool for near-continuous monitoring of PBL height
- Methods produce similar results, however WCT is more computationally efficient
  - Comerón et al. (2013) use linear system theory to prove WCT and GM are same [2]
- Residual layer (RL) is identified well with lidar
- Best results are shown in daytime, clear air convective situations
- Current work is underway to use an Extended Kalman Filter (EKF) to better track the PBL
  - developed and tested at UPC [3] in 2013

6. References

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