Typical tropospheric aerosol profiles over Southern Ireland: The UCC Raman LIDAR

Michael A.P. McAuliffe, Albert A. Ruth

Department of Physics and Environmental Research Institute, University College Cork, Cork, Ireland.

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Abstract:

A Raman lidar instrument (UCLID) was established at University College Cork and Raman backscatter coefficients, extinction coefficients and lidar ratios were measured within the period between 28/08/2010 and 24/04/2011. Typical atmospheric scenarios over Southern Ireland in terms of the aerosol load in the planetary boundary layer are outlined. The lidar ratios found are typical for marine atmospheric condition (lidar ratio ca. 20-25 sr). The planetary boundary layer ranges between 600 m and 1200 m and is comparably low. On the 21st of April a large aerosol load was detected, which was assigned to a Saharan dust event based on HYSPLIT trajectories and DREAM forecasts along with the lidar ratio (70 sr) for the period concerned. The dust was found at two heights, pure dust at 2.5 km and dust mixing with pollution from 0.7 to 1.8 km with a lidar ratio of 40 – 50 sr. Aerosol events, such as Saharan dust, volcanic particles (Eyjafjallajökull), forest fires, marine aerosols and anthropogenic particles have been detected with UCLID.

Lidar design:

A Raman lidar operating at 532 nm (elastic) and 607 nm (Raman) for the detection of aerosol has been in operation since early 2010 at University College Cork. The lidar is part of EARLINET and has partaken in the software analysis comparison [1]. Fig. 1 shows the setup of the lidar. Table 1 lists the main parameters of the system, while Fig. 2 shows a schematic of the lidar. Climatology measurements for EARLINET are performed weekly, weather permitting.

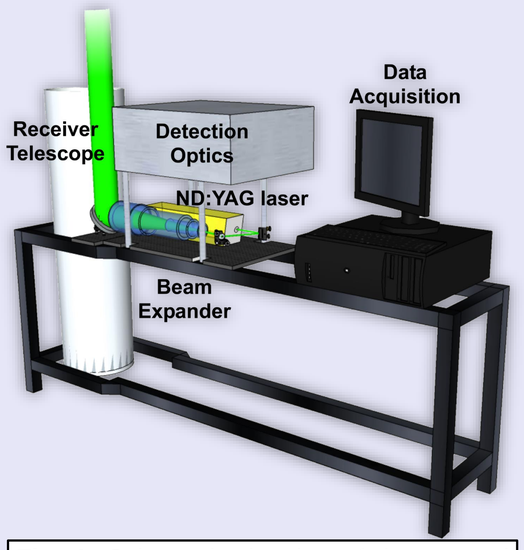

Fig. 1. Schematic drawing of the aerosol Raman lidar.

Table. 1. Components and specifications of the UCLID system.

Emitter		
Laser type	Nd:YAG	
Repetition rate/Pulse length	20Hz	10 ns
Wavelength/Pulse energy	532 nm	150 mJ
Receiver Optics		
Telescope type	Newtonian Reflector	
Telescope diameter	0.3 m	
Focal length/Field of view	1.5 m	0.73 mrad
Detection channels	532 nm	607 nm
Scattering mechanism	Elastic	Raman N2
Passband bandwidth – fwhm	0.5 nm	0.15 nm
Detector type	PMT2	PMT1
Detector manufacturer	Hamamatsu	Hamamatsu
Detector model	H5783P	H7422P-40
Data Acquisition		
Photon counting count-rate	200 MHz	200 MHz
Manufacturer	FastComtec	FastComtec
Raw data range resolution	30 m	30 m

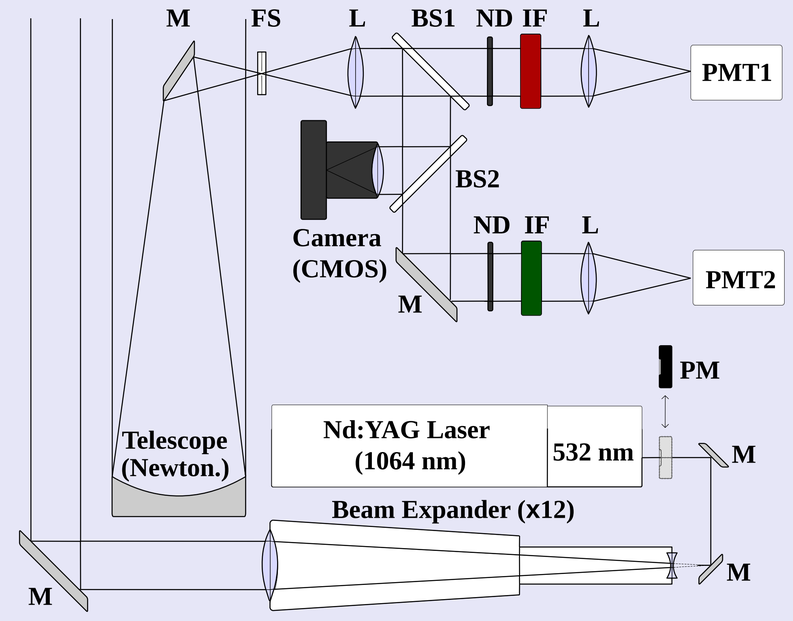

Fig. 2. Schematic of the Raman lidar system UCLID. PM: power meter (optional) FS: Field stop (diameter 0.9 – 5 mm, corresponding FOV 0.6 – 3.33 mrad). L: Lens, BS1. Dichroic beam splitter BS2: Beam splitter (50:50 ratio). ND: neutral density filters (optional), IF: Interference filter (narrow band), PMT: photomultiplier tube .

Backscatter and lidar ratio profile:

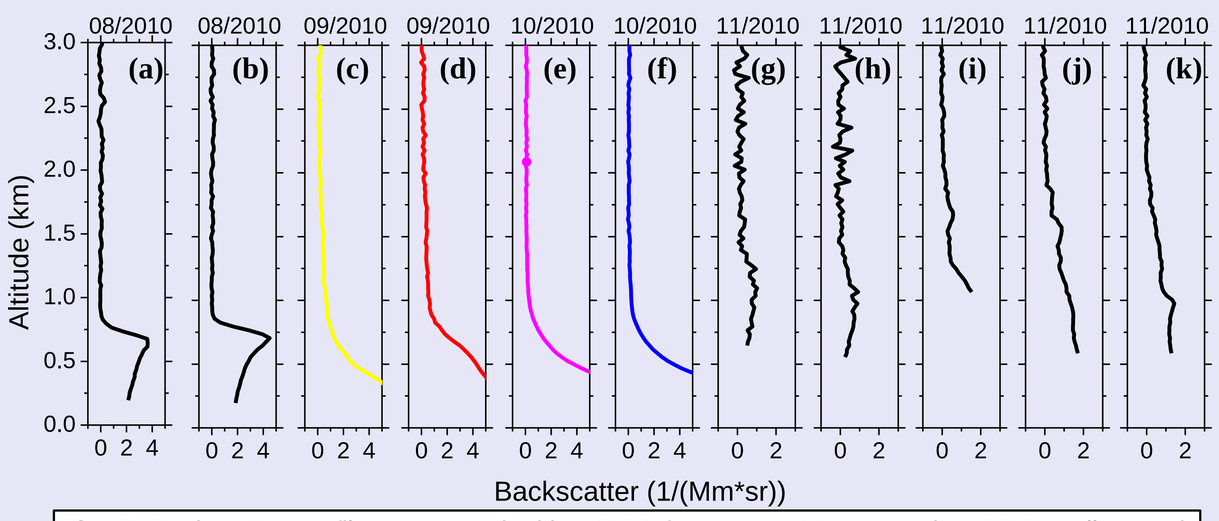

Fig. 3. Backscatter profiles measured with UCLID from August to November 2010. Yellow, red, pink and blue traces correspond to the lidar ratios in shown in Fig. 4.

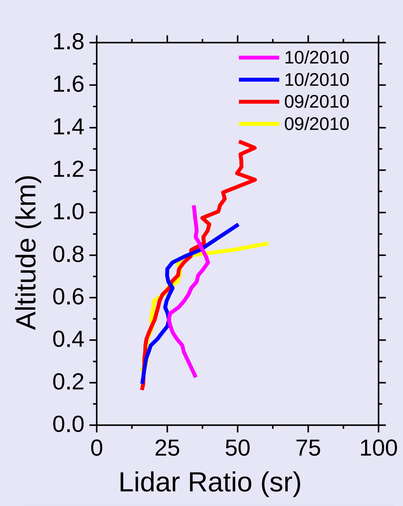

Fig. 4. Lidar ratio measured at Cork for backscatter profiles Fig.3 (c-f)

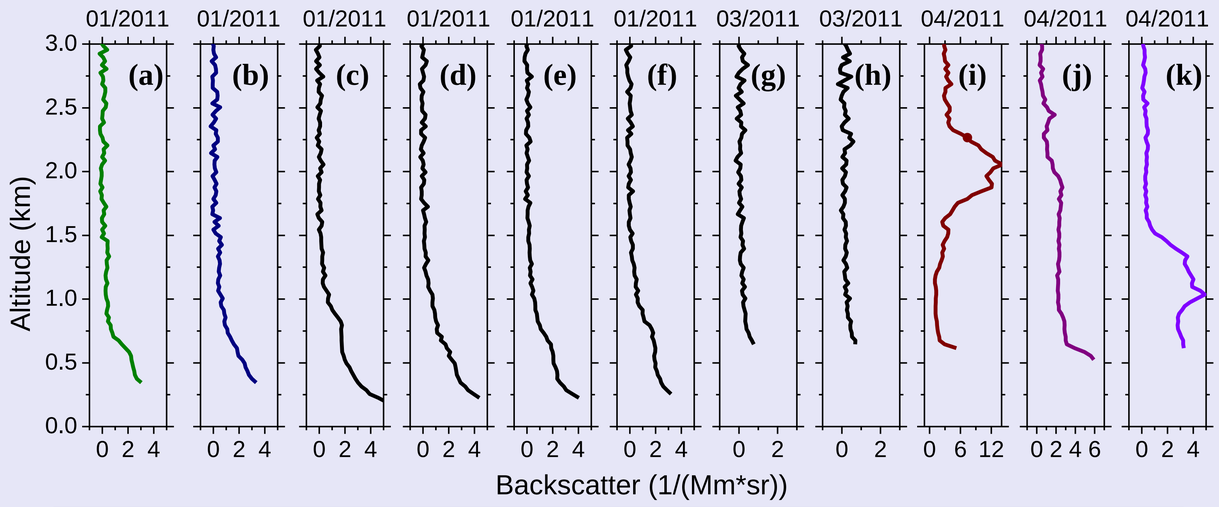

Fig. 5. Backscatter profiles measured with UCLID from January to April 2011. Green, navy, wine, purple and voilet traces correspond to the lidar ratios in shown in Fig. 6.

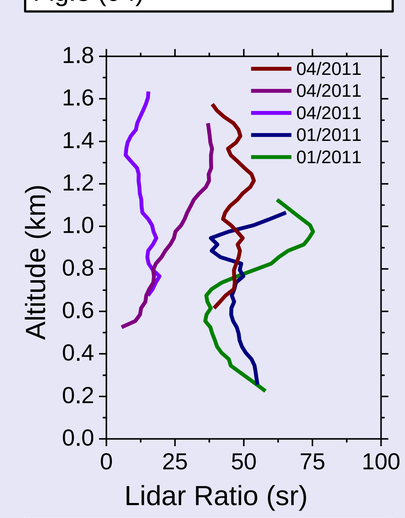

Fig. 6. Lidar ratio measured at Cork for backscatter profiles Fig.5 (a),(b), (i-k).

Table. 2. Description of aerosol occurrences as per Fig. 3 and 5.

Figure	Type of aerosol in profile
Fig. 3 (a), (b)	Local anthropogenic particles
Fig. 3 (c), (d), (e), (f)	Illustrates the most common backscatter profiles measured i.e. no aerosol loads in the troposphere and very low planetary boundary layer (PBL)
Fig. 3 (g), (h), (i), (j), k)	Profiles with mixed aerosols in the PBL or the lower troposphere
Fig. 5 (a), (b), (d), (e), (g), (h)	Profiles with clean troposphere and low PBL
Fig. 5 (c), (f)	Marine aerosol layers
Fig. 5 (i)	A large layer between 1.7 – 2.2 km was detected originating from the Saharan desert
Fig. 5 (j)	A dust layer at 2.5 km and local anthropogenic particles mixing with the lower troposphere and PBL
Fig. 5 (k)	Local anthropogenic particles

Figs. 3 and 5 show samples of backscatter profiles measured with UCLID from August 2010 to April 2011. Fig. 4 and 5 shows lidar ratios (LR) determined from the extinction and backscatter profiles. Typically LR for Cork are between 15-30 sr, which is expected for a marine climate. Dust layers give a LR of between 60-75 sr. A mix of local pollution has a LR between 40-50 sr [2].

Weather considerations for Cork:

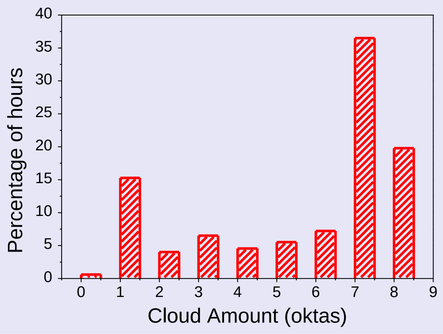

Fig. 7. Histogram of cloud cover over Cork from 2010 – 2011.

Located in the Atlantic at the western edge of Europe (51.53N 8.29W), the Cork station is of obvious geographic importance as an entrance point of air masses into continental Europe from a north-westerly direction. The polar front is a feature of the atmospheric circulation which plays an important part in determining Irish weather. It is a zone of transition between warm, moist air (sometimes of tropical origin) moving northwards and colder, denser, drier air (usually of polar origin) which is moving southwards. This gives the sequence of cloudy, humid weather with rain, followed by brighter, colder weather with showers so typical of the Irish climate. Fig. 7 illustrates the amount of cloud cover at the Cork site (2010 – 2011), while Fig. 8 shows the wind speed and directions for the same period.

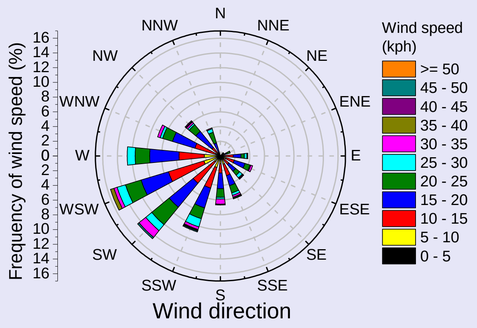

Fig. 8. Wind direction and occurrences of wind speeds for Cork from 2010 to 2011.

References:

[1] G. Pappalardo, et al., Aerosol Lidar Intercomparison in the Framework of the EARLINET Project. 3. Raman Lidar Algorithm for Aerosol Extinction, Backscatter, and Lidar Ratio. Appl. Opt., 43 (2004) 5370-5385.

[2] C. Weitkamp, Lidar: range-resolved optical remote sensing of the atmosphere. Springer, Berlin, (2005).