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Preliminary Results from the Ozone Lidar at the University of L'Aquila.

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Summary. — We describe the ozone lidar operated at the Department of Physics of the University of L'Aquila. Preliminary ozone profiles obtained with the DIAL (differential absorption lidar) technique are also reported and a comparison is made with ECC (electro chemical cell) sonde data obtained at the FISBAT, CNR in Bologna. Although this comparison is of limited value the two sets of data show a good agreement. The influence of the recent detected volcanic aerosols from the eruption of Pinatubo on these measurements is also discussed.

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Introduction. – The Lidar Station of the University of L'Aquila (SLAQ from now on) is located 42° N, 13° E at 700 m above sea level, in Preturo near L'Aquila. At the beginning of 1990 beside the already operating lidar system for stratospheric-aerosols profiles measurements, the development of a DIAL system was started for stratospheric-ozone measurements [1]. Nowadays the lidar and its implementation in the DIAL technique are well established both from technical and data analysis point of view [1, 2]. However the total number of lidar stations is limited especially outside the mid-latitude band in the Northern hemisphere. DIAL ozone stations operating at the present time are even more sparse so that it is rather important the operation of a new measuring station of this kind. An ozone lidar has several advantages with respect to the classical balloon sounding technique especially in terms of costs, reliability and amount of data. This makes the DIAL technique particularly suitable to validate data taken with classical instrumentation and as ground truth for satellite data. In this sense the lidar station described here has been selected as one of the ground truth stations for the Correlative Measurement Program of the Upper Atmosphere Research Satellite (UARS). In particular the ozone lidar will be used to validate similar data taken by the UARS.

SLAQ *experimental system.* – A schematic arrangement of the DIAL system for ozone measurement operating in SLAQ is reported in fig. 1. The active part of the system is an excimer laser (Lambda Phisik model EMG 150 MCS). This is a double-cavity laser that simultaneously produces emission of laser pulses at the wavelengths of 308 nm and 351 nm. The single-pulse duration is ≈ 20 ns and the single-pulse energy is 90 mJ for the

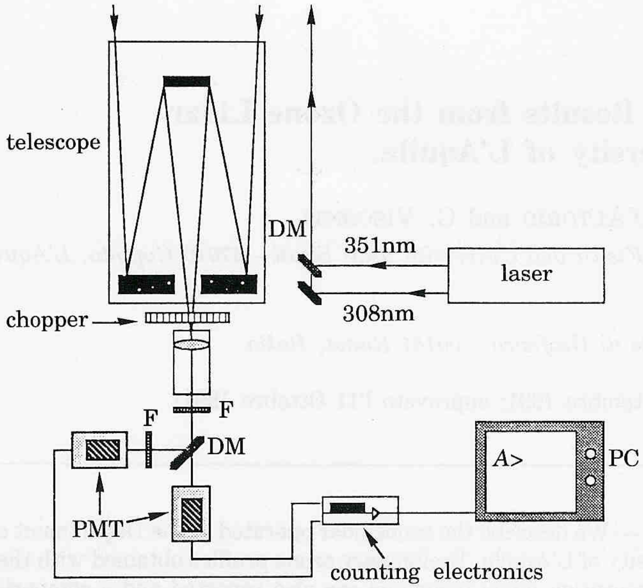

Fig. 1. – Schematic diagram of the University of L'Aquila DIAL system for ozone measurements. F = optical filters; DM = dichroic mirrors.

308 nm wavelength, and 70 mJ for the 351 nm wavelength. The two pulses are simultaneously transmitted in the atmosphere to sample the same air parcel of the backscattering medium and the two laser beams are superimposed by using a dichroic mirror.

The backscattered signals are collected by a 1 m, *f*/10 Cassegrain telescope. In order to reduce the background noise, the spectral bandwidth of the receiver system is limited using an optical filter with a passband of 140 nm centred at the wavelength of 310 nm. A dichroic mirror, similar to the one present in the transmission system, is used to separate the two wavelengths in the received signal. A further improvement in the wavelength discrimination is obtained with a 70 nm filter in front of the 351 nm channel. Two UV photomultipliers selected for low noise are used to detect the signal and both are cooled

TABLE I. – *Characteristic of the* DIAL *system.*

Trasmitter	
operating wavelenghts	308, 351 nm
output energy/pulse	90 mJ (308 nm), 70 mJ (351 nm)
repetition rate	up to 40 Hz
laser	Lambda Physik EMG 150
Receiver	
telescope	1 m diameter, *f*/10 Cassegrain
spectral bandwidth	140 nm
detectors	EMI9804QB cooled photomultipliers
Data acquisition	
photocounting	PC-CARD-EG&G ORTEC ACE MCS

to $-25\,^{\circ}\mathrm{C}$ to reduce the dark current noise. A mechanical chopper is used to avoid the saturation of the photomultipliers caused by the strong signal that is backscattered by the lowest atmospheric layers. The chopper is synchronized with the emission of the laser pulses and the photomultipliers are blocked for an altitude range of $(10 \div 12)$ km.

The signals detected with the photomultipliers are analysed with a photocounting acquisition system composed by a preamplifier-amplifier, a pulse discriminator and a multichannel scaler system connected with a personal computer. The multichannel scaler system is triggered by the laser pulses and can be set to scan the appropriate altitude range with a suitable height resolution. The dwelling time is usually set at $2\,\mu\mathrm{s}$ with a corresponding height resolution of 300 m. The signals induced by the laser pulses are automatically summed up by the multichannel scaler system to reduce the volume of the stored data. The lidar data are analysed with the standard method of the DIAL technique [1, 3] to obtain the ozone profiles. Table I gives the main characteristics of the lidar system.

SLAQ *ozone profiles and comparison with ozone-sonde measurements*. – The lidar measurements are taken at night and the ozone profile is obtained averaging the lidar signal over $5\cdot 10^4 \div 1\cdot 10^5$ laser shots. With a laser pulse rate of 10 Hz, a single set of measurements (including the preliminary set-up of the instrumentation) takes about $(3 \div 4)$ h. In fig. 2 we report some of the results which have been obtained during summer 1991. The vertical resolution of the ozone profiles degrades with altitude from 0.3 to 3 km, while the indetermination in ozone values is estimated to be about $(3 \div 4)\%$ for the statistical error and about $(5 \div 8)\%$ for the systematic error [4, 5] which depends on the altitude. A classical method to validate the lidar ozone profiles is to compare them with balloon sonde data taken possibly at the same site at the time of lidar operation. In our case the nearest site where such data are available is the ERSA-CNR sounding ground near Bologna (S. Pietro Capofiume) that is about 300

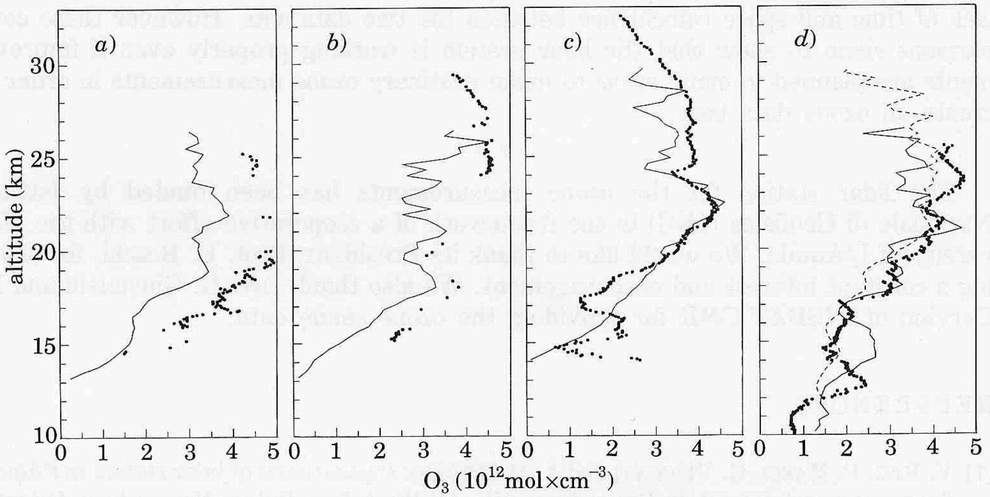

Fig. 2. – Comparison of DIAL ozone profiles with the ECC sonde data obtained at the S. Pietro Capofiume sounding station (Bologna). Comparison taken up to July 1st when the aerosol from Pinatubo eruption was not detected yet. *a*) —— DIAL, June 4, ··· ECC June 6; *b*) —— DIAL, June 21, ··· ECC June 20; *c*) —— DIAL, July 1, ···ECC July 4; *d*) lidar profile taken on August 16 (– – –) and 21 (——) compared to ECC sonde of August 19 (···). Some of the discrepancy in the $(13 \div 20)$ km range may be due to volcanic aerosol.

km from L'Aquila. Besides data are not taken at the same time and not even on the same day. However we do not expect ozone, especially below 30 km, to change considerably in time (on a time scale of a few days) and in space within a few hundred km so that with these limitations in mind the comparison could be still useful. Data of this kind cannot be used to test the appearance of single and peculiar features but mostly of the large-scale structure. The comparison is shown in fig. 2*a*)-*d*) between the DIAL and the ECC sonde. Notice that similarly to our station in L'Aquila also the balloon sounding has been started in the last few months so that both sites may be plagued with problems of calibration and of learning the measuring technique. Noise in the lidar data is large above 25 km in the initial profiles and some data is missing in the sonde-derived profiles due to balloon failure or transmitter and to data logging problems. However the data do show a remarkable coincidence which seems to improve with time. Notice that the precision of the ECC data is around $(10 \div 15)\%$ below 30 km and much larger above. In spite of some bias the main structures of the profiles are very similar. Figure 2*c*) shows a good coincidence of the two kinds of measurements and the same in fig. 2*d*), even if the comparison is limited below 25 km. Notice also that the July and August lidar data may be influenced by the presence of volcanic aerosol from the Pinatubo eruption detected at our site with the aerosol lidar since July. This layer presently located at the $(15 \div 16)$ km altitude range may affect the retrieval of the ozone profile in the altitude range between 13 and 20 km. Simulation using as input the aerosol profile measured at 590 nm shows that locally the retrieved ozone may change up to 50% of the «background» ozone values. Correction techniques are being developed to take into account such effect.

Conclusions. – We have described the present state of the DIAL system for ozone profiles measurement and preliminary comparisons with ECC sonde data. It is obvious that these comparisons are not the best chance to validate our system, due to the lack of time and space coincidence between the two data sets. However these comparisons seem to show that the lidar system is working properly even if improvements are planned in many areas to make routinary ozone measurements in order to create an ozone data base.

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