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A SHOT PER SHOT DIAL SYSTEM FOR OZONE MEASUREMENTS AND FOR A POSSIBLE DETERMINATION OF WIND FIELDS .

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INTRODUCTION

Many UV DIAL systems are engaged in the measurement of tropospheric ozone. The participants to the EUROTRAC-TESLAS program [1] are involved in an intercomparison of the performances of their instruments to improve both experimental and data analysis procedures [2,3].

As one major photooxydant [4] of the atmosphere, the evolution of the ozone concentration has been studied at different scales with photochemical models including the transport and the diffusion of chemical species [5]. The preparation of a wind field over the domain of analysis is a critical step of the modeling [6]. It is usualy based on data from baloons, sodars, or Doppler Lidars

A shot per shot Lidar has been developped at the EPFL [7]. Based on two excimer pumped Dye Lasers, it is presently tuned for tropospheric ozone measurements. It has been incorporated into the TESLAS collaboration. Thanks to a systematic recording and online treatment of each Lidar return, this instrument gives access to the two temporal dimensions of the Lidar measurement, as characterized by the sampling of the signal and its repetition.

In this paper, an overview of the innovative tools of investigation offered by this approach and a first ozone profile are given. The result of their application to a data set to be collected at the swiss meteorological station of Payerne in May 1994 will be presented at the conference.

EXPERIMENTAL SETUP

A first setup of the experiment is shown in the part A of figure 1. The used wavelengths for the ON and OFF resonances of a DIAL instrument and the time interval between them can be freely chosen. The backscattered light is detected by a 600 mm Cassegrain telescope. Daylight measurements are favoured by a spectrograph. A systematic shot per shot energy monitoring has been implemented. The telescope can be oriented around the azimuth and elevation so that the whole hemisphere can be probed. A second mirror has been introduced for the light collection as presented in figure 1 part B, to increase the dynamical range of the experiment by using an analog detection on the first telescope and a photon counting detection on the second one. As discussed below, the introduction of a second emission beam as presented in figure 1 part C could be used for the determination of wind speeds.

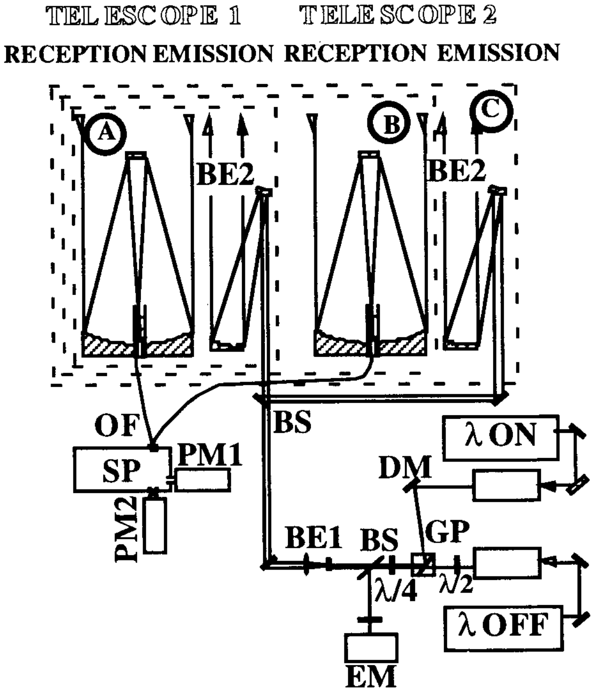


Fig. 1 Experimental layout for three different assemblies **A**, **B**, **C**. **BE**: Beam Expander; **BS**: Beam Splitter; **DM**: Dichroic Mirror; **EM**: Energy Monitoring; **GP**: Glan Prism; **OF**: Optical Fibers; **PM**: PhotoMultiplier tube; **SP**: SPectrograph.

Instead of a complete description of the electronic layout for the synchronization and the data taking of the experiment, a focus is made in figure 2 on the logic implemented for the shot per shot recording of Lidar returns in counting mode. Phototrigger signals are generated at the light emission with photodiodes. They are delayed before to trigger two 16 channels counting units for the ON and OFF returns respectively on the one hand, and two 8 channels gate generating units on the other hand. To increase the content of one channel of a scaler, a count must arrive during the activation of the corresponding gate.

This is obtained by the programmation of a logical AND between the line of the signal and the different gates. By choosing different widths for the gates, it is possible to reconstruct after an acquisition the number of counts obtained for time windows adapted to the application with a subtracting algorithm. The readout of the scalers is done through a high speed VME bus mastered by a R4000 processor. Analog converters with 8 and 12 bits of vertical resolution are implemented on the VME bus to record shot per shot sampled analog signals.

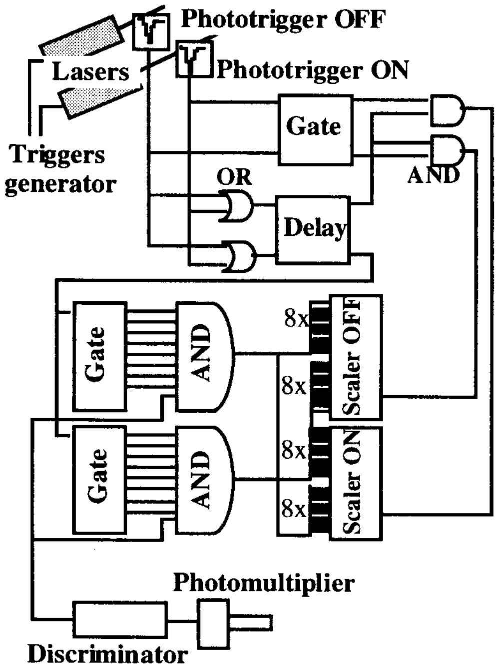
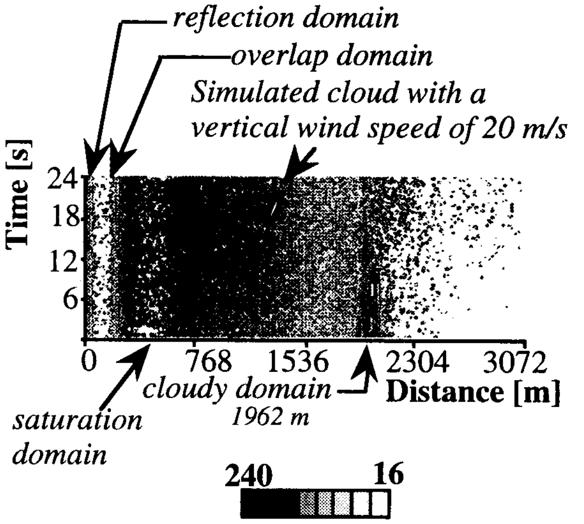


Fig. 2 Shot per shot MCS

RESULTS

A bidimensionnal contour plot for 2400 successive laser shots acquired with the setup 1 A and 8 bits ADCs is shown in figure 3. The two temporal dimensions of the system are represented one against each other with levels contours giving the intensity of the signal. A reflection of the emitted pulse in the laboratory is apparent at the origin of the sampling. It is followed by an increase of the sigal corresponding to a progressive overlap of the solid angles for the emission and the detection. A saturation is then visible, followed by the typical decrease of a Lidar signal. Clouds are present during the first 10s of the experiment around 2000m, acting as a barrier for the light. Such a representation of the collected data over successive laser shots provides a good mean for an overall qualitative appreciation of the signal fluctuations during an acquisition.

Quantitative information can be extracted from distributions of events as presented in figure 4 for the sampling channel corresponding to the distance of 1962m. The presence of a cloud appears as a peak of saturation. The distribution is shifted towards higher values than expected for a gaussian shape. This is a signature for the background. A mean μ and a standard deviation σ can be estimated from the



Contour scale [ADC counts]

Fig. 3 Bidimensional contour plot for 2400 OFF signal

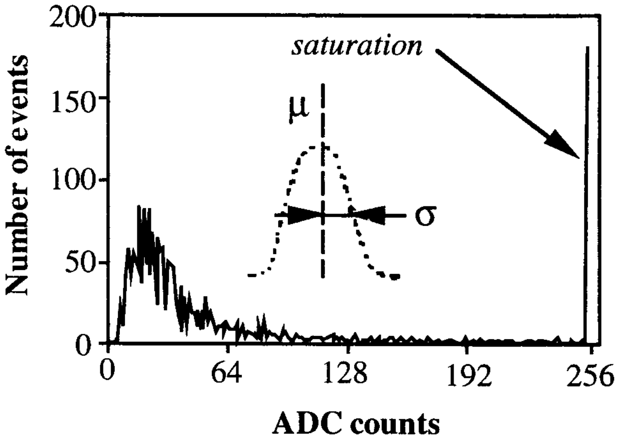


Fig. 4 Distribution of events at 1962m

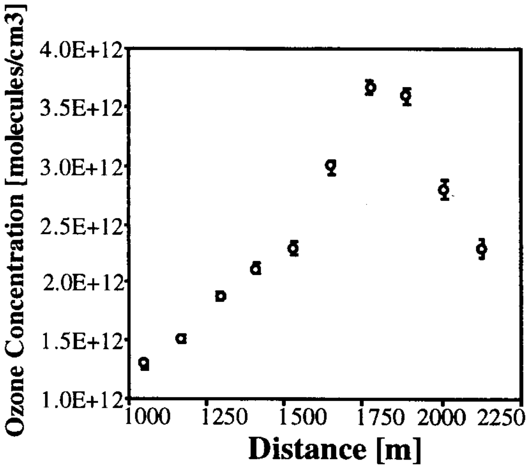


Fig. 5 Ozone profile with statistical errors

distribution after these effects have been taken into account.

An ozone profile is presented in figure 5 where only the statistical errors have been propagated.

WIND MEASUREMENT

The simulated effect of a cloud moving vertically at 20 m/s has been superimposed to real data in figure 3 to illustrate how a vertical wind could be measured from such a contour plot in cloudy meteorological conditions. The speed of the wind is directly given by the average slope of the pattern representing the moving cloud. The precision of the measurement is estimated from its width. The projection of the time evolution of the backscattered light at the distance of 1962 m is shown in figure 6a. The additional return of a system with a second beam separated by 100m from the first one at the distance of 1962m for a wind component of 20 m/s between the two beams is represented in figure 6b. This simulated signal is obtained by a simple shift of 5s in time of the measured signal given in figure 6a , to illustrate how wind speeds could be measured with a multibeam shot per shot system in cloudy conditions. To get simutaneously the two components of the wind speed in the horizontal plane (provided the light beams are vertical) requires the addition of a third beam.

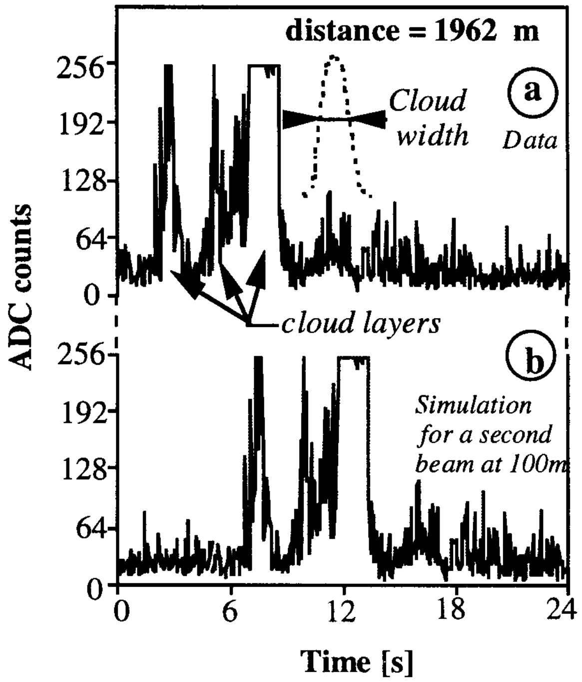


Fig. 6 Time evolution of the backscattered signal from 1962m.

Very simply illustrated with clouds, the feasability of this time of flight method to determine the speed of the winds must be further investigated to determine in which conditions it could be used with less intense signatures than provided by clouds by studying the correlations of the backscattered light from aerosol densities for example.

Once the wind field has been measured, the dotted lines in figure 6a illustrate how a distribution of the size of the clouds can be obtained with this method. From this single channel of analysis at 1962m, three clouds with respective widths of 20m, 10m, and 38m can be identified under the above assumptions. To improve the precision of the determinations for both the wind speed and the size of the clouds, the information from all the channels of sampling must be used.

CONCLUSION

A shot per shot Lidar system has been developped at the EPFL to provide data on tropospheric ozone for the validation of photochemical models of the atmosphere. The elaboration of wind fields is a critical step of the modeling, and the knowledge of the disribution of size of the clouds is essential to the simulation of the effects of the heterogeneous chemistry at their location. The simultaneous measurement of vertical profiles for these chemical and physical parameters with a shot per shot Lidar is of great help for the development of these models.

First ozone profiles have been obtained with a one telescope version of the instrument. The systematic shot per shot recording and online analysis of the data has appeared to offer original tools of investigation for a better quality of measurements: the statistical variability of the signals is known and systematic effects can be studied and corrected for when possible. The access to new physical variables such as wind speeds and clouds sizes requires experimental modifications to introduce at least two independant beams.

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