25PC5 EXTENDING THE CO_2 DIAL MAPPING CAPABILITY. OBSERVATIONS OF GASEOUS DIFFUSION OVER COMPLEX TERRAIN.

S. Egert, D. Peri, J. Sivan, Y. Baumgarten
Israel Institute for Biological Research
P.O. Box 19, Ness Ziona, Israel 70450

INTRODUCTION

Mapping of atmospheric tracers, natural trace gases and numerous man-made pollutants can be best performed by using a CO_2 LIDAR in a DIAL mode. The spectral characteristics needed to detect a single specimen or a mixture, fall in the 9-11μm range typical to CO_2 lasers emission (1). Two phenomena limit the DIAL mapping capability regarding concentration threshold, range and resolution. The first limitation is due to the low Lidar signals scattered from natural aerosols in the considered spectral range (related on the dependence of aerosol backscattering on the radiation wavelength). Low signals decrease the minimum signal to noise range, effecting both the concentration threshold and its achievable range. The second limitation arise from the relatively long CO_2 laser pulses, known as "Nitrogen tail", resulted from the inefficiency of energy transfer among the gases that are used in the laser mixture. The long pulse duration, smears the fine details in the LIDAR signals, due to the temporal convolution process involved. Hence, limitations are imposed on the range resolution even at close ranges. Therefore, though the spectral region of this LIDAR is optimal, long range observations can be rarely performed (2).

Meanwhile, estimation of the atmospheric composition and its temporal evolution both for natural and man made pollutants, becomes a crucial necessity. Hence, direct measurements of the pollutants and understanding of atmospheric behavior are required. Therefore, development of practical methods is necessary to overcome the limitation described, enabling the CO_2 LIDAR operation in the spectral region which is convenient for all these measurements.

METHOD AND APPLICATIONS

The method described below, offers a solution for the DIAL range extension based on hardware level. The method was demonstrated while mapping the atmospheric SF_6 tracer, diffused over natural topography and complex terrain land cover. The line of sight (LOS) of the Lidar was chosen to cover the predicted plum center and its central margins. The Lidar observations, were first related to the measurements of the large SF_6 point detector network surrounding it, based on former calibrations (3). Than LIDAR mapping was used as complementary information to the point detectors showing the possibility to interlace the complicated maps. Diffusion release point was located on the slope at the back of a hill, where the LIDAR LOS was located on its front. The distance to the LOS was about 1.2Km, and the height of the hill extending over this distance was 200m.

The tracer could be spectrally detected using a CO_2 LIDAR, but good coverage of the large terrain observed, demanded long LIDAR LOS. Moreover, the expected shape of the cloud was large, irregular and the concentration levels were lower or close to the Lidar threshold.

The proposed mapping method is based on the reflection of LIDAR signals from hard targets placed at consequent ranges along the LOS. Their reflection coefficient can be orders of magnitude higher than the natural aerosol backscattering. Thus, enlargement of the signal to noise ratio is achieved while mapping distant phenomena. Principally, these targets can be either natural or man made, having smaller dimensions than the LIDAR beam span. The targets should be placed at successive distances along the LOS in a non overlapping configuration, allowing simultaneous mapping. The average concentration over the distance between consequent targets, can be drawn from the integral over path calculated for each target. Fig 1. shows a schematic view of a possible targets layout within the LIDAR FOV. This layout takes advantage of the relatively large transmitter angle, offering convenient backscattering level from high but narrow targets. Other possible layout may utilize low and wide targets producing the same effect on successive heights along the Lidar LOS. Hence, an optimal layout of natural and man made targets can be planned at the site, according to its natural capabilities. When man made targets are considered, their characteristics can be optimized even when unsophisticated materials are used.

For the diffusion test described, 90° angular metal posts forming primitive retro reflectors, were used. The wings of the posts placed at consequent ranges, were increased in size, to compensate for the reflected signal decrease with range. Thus, the signals observed from the seven targets covering close to 2 Km range were similar, enabling signal detection over a small system dynamic range. Though method application is usually limited in height and produces coarse spatial resolution, it provides an easy estimation to the temporal changes over the LIDAR LOS.

Results of two rounds from the complex terrain diffusion test, carried in different atmospheric stability conditions, will be analyzed. Algorithms for accurate real time mapping, together with interpolation procedures will be discussed. Calibration of the Lidar and point detectors including combined operation, was carried out in controlled conditions and tested in a verification field test (3). Fig 3. gives the an example regarding temporal variation of the SF_6 concentrations observed using Lidar and point detectors. LIDAR mapping capability is demonstrated on fig. 2a. while fig. 2b gives the information measured by a point detectors belt situated 500m downwind. Fig. 2a and 2b exhibit the difference in concentration fluctuations over these lines measured on the same time scale, due to their different range and topographical height. Natural aerosol mapping that was carried out on a close LOS, could not be analyzed since the cloud was far from the LIDAR and its concentration levels were low.

The method demonstrated can be applied to various experiments and measurement sites. Pollution monitoring over urban and industrial zones has advantageous field layout, offering natural targets. For higher or constant resolution, man made targets can be easily added. Thus, the capabilities of the CO_2 spectral region and the fast temporal resolution of the LIDAR can be applied to monitor over the ranges that are practically needed. The possibility to interlace the information with that of other means, ensures the adequate coverage, even for complex sites.

REFERENCES

(1) W. B. Grant, R. H. Kagann, "Optical Remote Measurement of Toxic Gases" J. Air Waste Manage. Assoc. 42, 18-30, 1992.
(2) Y. Zhao, M. J. Post "Receiving Efficiency of Monostatic Pulsed Coherent Lidars 1&2" Appl. Opt. 29,4111, 1990.
(3) S. Egert, D. Peri "Comparative Open Path Environmental Monitoring Using Lidar, IR Radiometer and Point Detectors" Accepted for Publication Proc. SPIE- Air & Waste 1994.

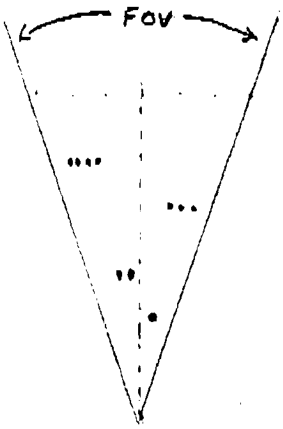

Fig 1. Targets layout

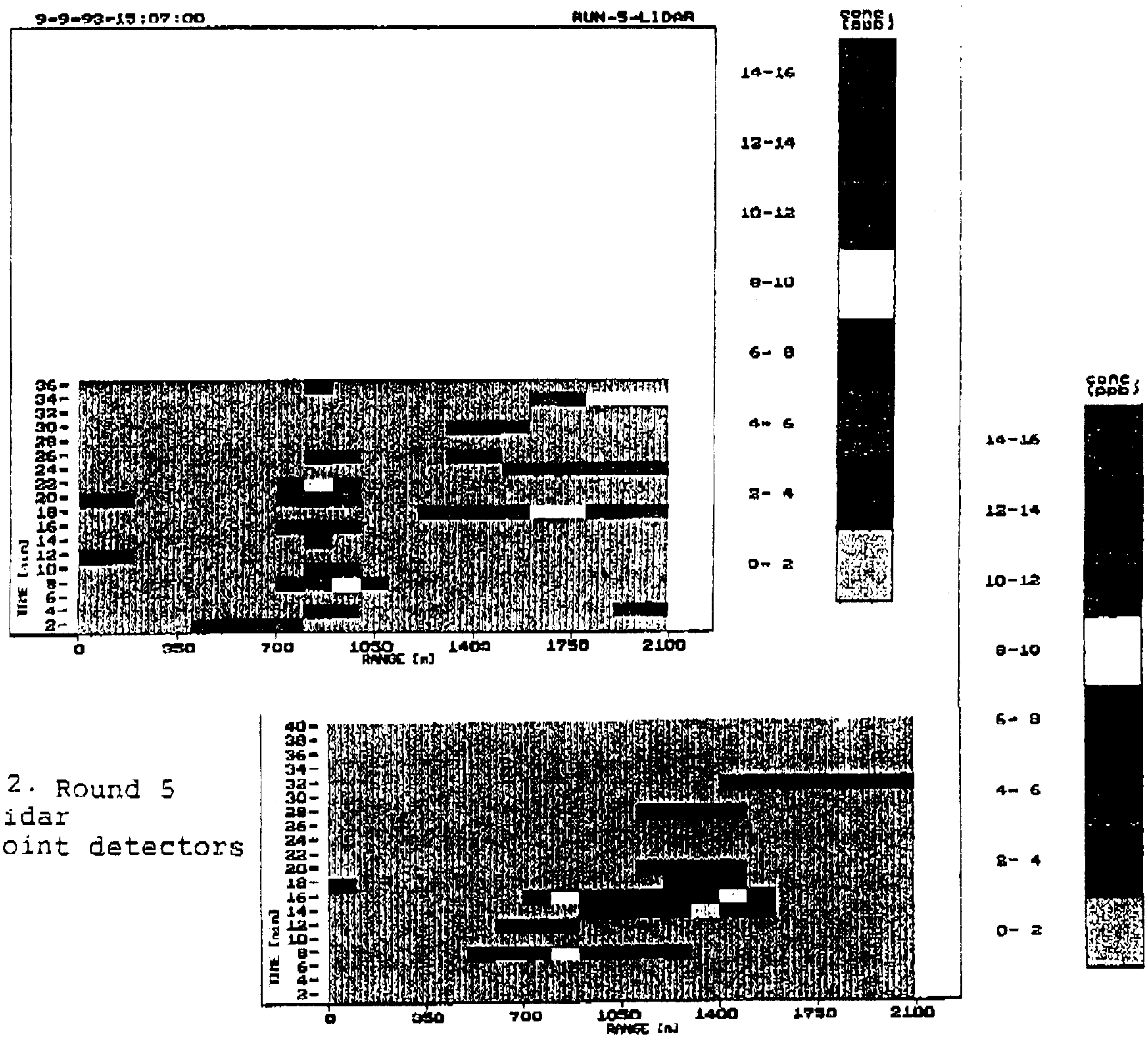

Fig 2. Round 5
a. Lidar
b. Point detectors