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AEROSOL EXTINCTION PROFILING WITH CO_2-LIDAR

Arne Hågård and Rolf Persson
National Defence Research Establishment
Dept. of Information Technology
P.O. Box 1165, S-58111 Linköping, Sweden
Phone: 46 13 318000 Fax: 46 13 131665

INTRODUCTION

The atmospheric IR-transmission is an important parameter for the prediction of detection range of IR imaging systems. With the aim to develop a model for the aerosol extinction in slant paths in the lower atmosphere we therefore perform measurements with a CO_2-lidar. Earlier measurements with a transmissometer along horizontal paths have been used to develop a model, which relates the aerosol extinction to weather parameters. Ref. 1 and 2.

LIDAR SYSTEM

The lidar radiation source is a TEA CO_2-laser. The pulse energy is 200 mJ and the main pulse length is 170 ns. A tail, which is < 1 μs long, follows the main pulse. The P20 line with the wavelength 10.6 μm is normally used. The receiver is a telescope with 30 cm aperture diameter, and a nitrogen cooled CMT-detector for incoherent detection. A scanning mirror system enables scanning of the lidar lobe in azimuth and elevation. Signal processing is performed through a linear amplifier, a digitizer for 8 bit, 100 MHz, sampling and a PC. To improve the signal to noise ratio and the dynamic range, a number, typically 100, of single pulse returns are added for averaging before further processing.

MEASUREMENT METHOD

To provide data for the calculation of vertical profiles of the extinction coefficient α, measurements are performed with the lidar-lobe pointing in three ore more directions. A horizontal path return is used to obtain the extinction coefficient α_G at ground level. A net, which is placed at 1 km distance, is used for calibration. An offset signal, which is recorded with the laser beam blocked, is used for correction for interference and drift in the digitizer circuits. The offset signal is subtracted from all lidar returns. The lidar sytem function is obtained from a horizontal path return in homogeneous atmosphere with low extinction.

A return from a path with high, near vertical, elevation angle is used to calculate an approximate vertical α-profile. Calculation is done by forward inversion using α_G as boundary value. Lidar returns from one or more slant paths with different elevation angles are then used to calculate the final extinction profiles.

INVERSION

The aerosol extinction is assumed to be approximately horizontally homogeneous, constant, at an altitude h_m, and the value α_m is taken from the approximate vertical profile. This value is now used as far end boundary value in calculation of the extinction coefficient by backward inversion for the slant path returns. The normalized lidar return q(r) is calculated by division with the system function and correction for water vapour absorption. The extinction coefficient $\alpha(r)$, where r is range, is then obtained as:

$$\alpha(r) = \alpha_m q(r) \Big/ \left(1 + 2\alpha_m \int_r^{r_m} q(x)dx \right)$$

where α_m is the boundary value at range r_m and altitude h_m.

The laser pulses from the TEA laser are relatively long particularly with the tail included and therefore the correct lidar equation should include a convolution integral with the pulse function. Ref. 3. The influence of the pulse shape on the inversion of the lidar equation and on the obtained extinction profiles is studied by numerical simulation. Methods for correction, deconvolution, will be discussed.

RESULTS

In the figure on the next page an example is shown of a field of α values in a vertical sector, which were measured with the described method. A haze layer with its maximum density around 200 m is displayed. Due to site conditions the vertical angle was limited to 28°.

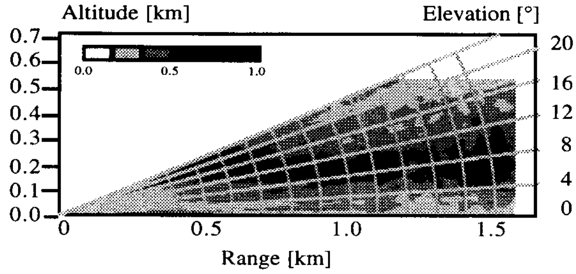

Figure. Extinction coeff. α in vert. sector.

By simultaneous measurements with lidar and instruments for weather parameters and sun irradiation we will generate a data base, which can be used for for investigation of the relation between aerosol extinction profiles and environmental parameters in the boundary layer. The intention is to use these data for the development of a model for calculation of transmission in slant paths and range prediction for IR systems.

REFERENCES

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3. Y. Zhao and R.M. Hardesty, "Technique for correcting effects of long CO_2 laser pulses in aerosol-backscattered coherent lidar returns", Appl. Opt., Vol. 27, No. 13, 1 July 1988.