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LIDAR MEASUREMENT OF WIND VELOCITY BY TRACKING A SINGLE CLOUD MOVEMENT

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INTRODUCTION

A ground-based LIDAR system has recently been developed to measure various atmospheric parameters such as wind velocity, aerosol distribution, Ozone, and air pollutants unique to Hong Kong environment. This system is presently situated at a fixed observation site of the City Polytechnic of Hong Kong (CPHK) to measure the wind velocity of lower atmosphere by selecting a targeted cloud nearby at an altitude of 800 meters and a distance of 1000 meters. We propose to measure the wind velocity by using a simple approach of tracking a single cloud movement under favourable visual conditions.

The status of the development including the design and specifications of this LIDAR will be first described in this paper. Then, the preliminary experimental results of measuring the wind velocity using our proposed approach and its principle will be presented. We further propose to use this technique for low-level wind shear detection unique to Hong Kong atmosphere.

THE FIRST LIDAR IN HONG KONG

The basic LIDAR station consisting of a transmitter, a receiver, and a data acquisition and processing system is shown in Figure 1. The transmitter is based on a Nd:YAG laser which is doubled to 532 nm with pulses of 10 ns at repetition rate of 10 Hz. The output beam energy of each pulse is about 100 mJ and is directed into the optical system which provides a collimation and a 5x magnification for transmission into the atmosphere via a scanner. The receiver is based on a 0.25m Newtonian telescope which is also aligned coaxially with the output laser beam. The focal spot-size of the incoming optical image can be varied from 0.5 mm to 3 mm in diameter corresponding to receiving angles of 0.3 to 1.8 mrad respectively. A high gain photomultiplier with appropriate interference filters for the wavelengths of interest in the visible and near UV. The received signals are amplified and then digitized at 15 m range intervals with an 8-bit A/D converter.

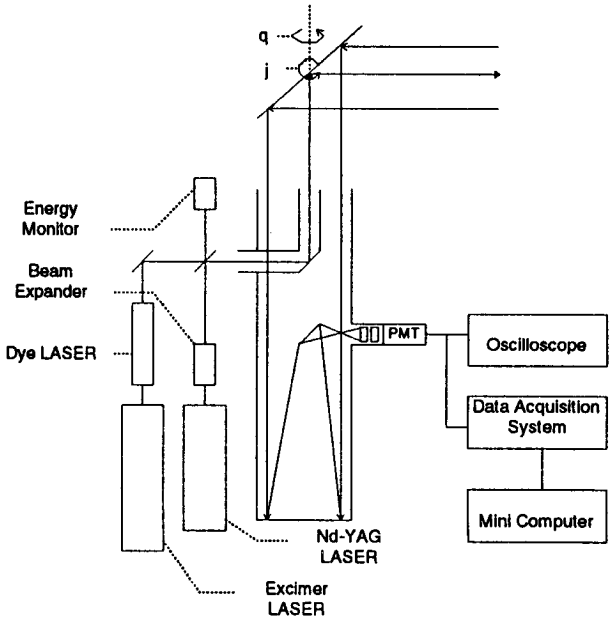


Fig.1 The schematic diagram of the basic LIDAR station.

The beam scanner consists of a single flat mirror of 0.30 m with the capability to slew the transmit and receive lines of sight of the LIDAR within 10 degrees to provide the elevation scan and the azimuth scan capabilities. The scanner is controlled using a standard microcomputer linking to the motor driver unit. However, this LIDAR station is immobile and spectral-limited at its early developmental stage.

WIND VELOCITY MEASUREMENT

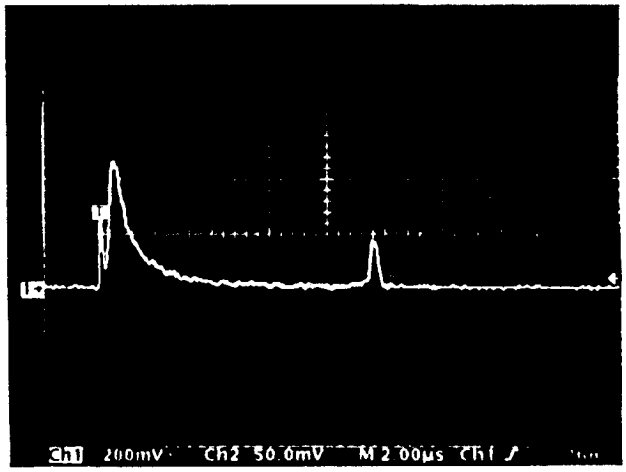
The basic principle for the proposed wind velocity measurement is based on the tracking of a targeted single cloud's movement. By measuring the signals from the back-scattered light corresponding to the targeted cloud's displacement at two different instances, both radial and lateral velocities can be determined. By assuming that the maximum back-scattered signal captured using a high-speed storage oscilloscope is the line-of-the-sight location of the targeted cloud at one instance, the scanner can slew a fixed angle to receive the corresponding signals (see Fig. 2). Thus, the wind velocity can be determined by combining the two velocity components. Our preliminary result using this approach indicates that the measured wind velocity is quite reasonable.

As an example, consider the signals in Fig. 2. Based on the time difference between the two signals, it is determined that the wind component along the line-of-sight is 0.8 m s^{-1}. The mirror is then rotated to capture the signal again. From the displacement of the cloud and the time it takes for it to travel that distance, the wind component is estimated to be 3.5 m s^{-1}.

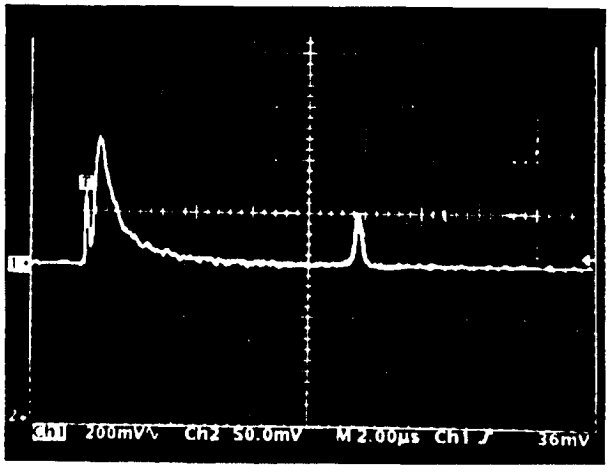
SUMMARY AND FUTURE WORK

A ground-based LIDAR system for measuring wind velocities at different altitudes has been developed for Hong Kong. By making use of clouds as targets, the determination of the wind velocities appears to be possible.

The system has just gone through its development stage. In the coming few months, more measurements of wind velocities at different heights under different meteorological conditions will be made. These results will be presented at the Conference.



(a)



(b)

Fig.2 Back-scattered LIDAR signals from a targeted cloud. (a) at the beginning of the tracking, (b) at a later time. The second peak is the received signal.

One of the original objectives of this project was to develop a mobile LIDAR system. This will be the next step when the current setup is further tested. The plan is to install the system on a vehicle so that it can be used to measure wind velocities at various locations over Hong Kong.

Although not reported in this paper, the system at present is also capable of measuring the aerosol concentration in the atmosphere. Once calibrated, the mobile station will also be used to measure the aerosol concentrations at different locations in Hong Kong under different meteorological conditions.

The last major plan of the project is to replace the current Nd-YAG laser with an excimer laser so that trace gas concentrations can be measured. This will involve replacing the optical components with those that are transparent to UV light.

ACKNOWLEDGEMENTS

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