1.06μm AEROSOL DOPPLER LIDAR FOR WIND MEASUREMENT

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ABSTRACT

A 1064nm aerosol Doppler wind lidar system based on the double edge technique is built up at Anhui Institute of Optics and Fine Mechanics, China. An FP (Fabry-Perot) etalon is used as the frequency discriminator, which analyzes the Doppler frequency shift from the atmospheric aerosol movement by wind. The lidar system construction is described in the paper. The frequency respond curve of the receiver has been measured for over 20 days, and it shows a stable receiver construction including the etalon. The laser frequency is locked to the cross point of the dual etalon transmission curves in each measurement. The receiver for the frequency measurement is calibrated by the known line-of-sight (LOS) Doppler shift produced from a rotating disk, and the calibration accuracy in velocity is less than 1% in the range of ±40m/s. The field wind observations are carried in the clear weather, and it shows a good coincidence with radar data.

1. INTRODUCTION

The atmospheric wind data is clearly one of most important parameters for the applications such as meteorology research, climate study, and the atmospheric sciences. Comparing to the other wind remote sensors, lidar remote sensing is so far the only tool that is able to directly measure Doppler wind in the global region. A 1064nm aerosol Doppler wind lidar with direct detection system has been developed at Anhui Institute of Optics & Fine Mechanics, CAS, Heifei, China [1]. The system is built up on the roof of the main building of the institute (117.16E, 31.90N). The lidar has operated and observed the wind profile in routine period.

The lidar system uses a dual FP etalon as frequency discriminator. The Doppler shifted frequency caused by the aerosol movement from wind is analyzed by the discriminator, and the line-of-sight (LOS) wind velocity could be found. The system is designed to measure the wind profiling of the low troposphere, and aimed at the verification of the abilities of measuring the field wind speed by the aerosol backscattering. The system details are described here. The velocity calibration has been introduced. Some examples of the comparison of the wind profile with other tools in the local area such as conventional radar will be also shown.

2. DESCRIPTION OF THE SYSTEM

The 1064nm aerosol Doppler wind lidar was fully built up in March 2004. The lidar system consists of four parts, the laser transmitter, the scanner and telescope, the FP etalon receiver and the controlling sub-systems, as shown in Fig.1. The laser beam from a seeded Nd:YAG continmuum laser Model 8050, is expanded by an 8X expander to compress the beam divergence to less than 0.1mrad, and gets through a reflect mirror mounted in a Cassegrain telescope and points to the atmosphere by a two-dimension scanner. The received backscattered light is coupled to a 100μm multimode fiber connected to the receiver. The collimated light passes through the interference filter (IF) with the bandwidth of 0.5nm@1064nm. The light is split to two beams by the 80/20 (T/R) BS (beam splitter), and the 80% light is incident on to the dual FP etalons with balanced intensity for each, respectively and then detected by two photon counting mode Si:APD detectors, respectively. The rest 20% light is detected by the monitor detector, a photon counting mode Si:APD. Little part of transmitted laser light is coupled directly into the receiver through an optical fiber, and used as the reference frequency. The operating commands of laser shooting, XY scanner and FP etalon are sent out by the computer through RS232 interface.

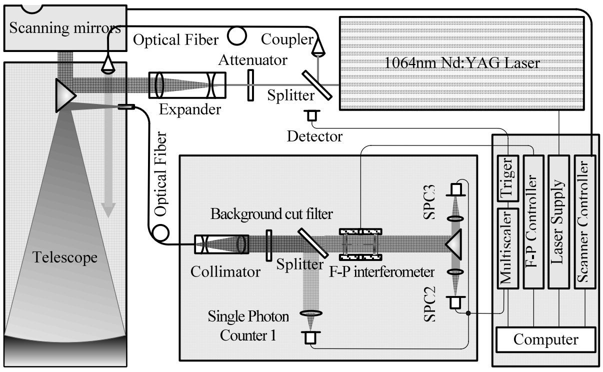


Fig.1. Diagram of the aerosol Doppler lidar system.

Table I lists the parameters of the lidar system. Parameters of the frequency discriminator (i.e. the dual etalon) are designed by considering the speed dynamic range, optimized velocity sensitivity, and backscatter light intensity or the signal-to-noise ratio. The dual etalon is air-spaced. The etalon structure is designed as

D shape with semi-circle for each channel. Two semicircle cavity lengths are slightly different to obtain the designed transmission properties [2]. This difference has been measured to be about 32.5nm, which corresponds to the central interval of about 200MHz.

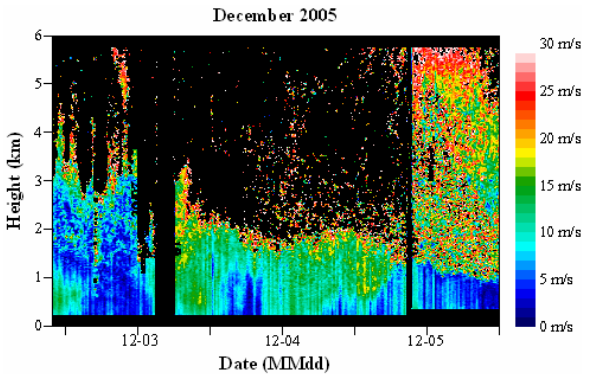
Table I. Parameters of the aerosol Doppler lidar system

Item	Parameters
System	
Zenith angle	45°
Wavelength	1064 nm
Laser energy	100 mJ/pulse
Laser beam divergence	0.5 mrad
Optical efficiency	80%
Receiver	
Telescope diameter	ϕ300 mm
Detector type	Si:APD
Quantum efficiency	18%
Etalon FSR	3.5GHz
Etalon FWHM	190 MHz
Etalon center interval	200 MHz
Etalon peak transmittance	>60%

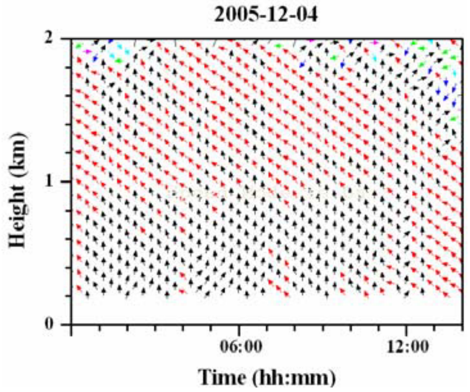
The stability of the transmission properties of the two etalons seriously affects the accuracy of the frequency measurements. As the frequency of seeded laser is slowly changed by the environmental temperature, the transmitted laser frequency must be locked to the etalon curves. Usually the laser frequency is located at the crossing point of the two transmission curves. During the wind measurements the frequency of the reference light from the transmitted laser is determined by the etalon transmissions, the program will calculate the laser frequency if in the right position. When the laser frequency is changed by the temperature, the transmission will be different and the computer will controlled the etalon cavity length back to the cross point. The direction and magnitude of the frequency changing could be determined by comparing the transmittances of two etalons. In this way the effect of the long term frequency fluctuation could be minimized.

3. WIND OBSERVATIONS

The aerosol Doppler lidar system is automatically controlled by a computer. The lidar takes the measurements of the line-of-sight (LOS) wind speed in 3 directions with the interval angle of 120 degrees in horizon and at a fixed elevation angle of 45 degrees. The LOS Doppler frequency or speed could be retrieved principally from the discussion of C.L. Korb [3]. One could then deduce wind vector (magnitude and direction) from the three direction LOS wind measurements. The wind profile will be taken in every 10 minutes and each measurement will spend about 5 minutes. The returned signal is with 30 meters range resolution. The lidar was fully started operating by November 2005, and many day continuous operations have been carried out. Fig.2(a) is an example of wind profiles of speed and direction obtained from December 3 to December 5, 2005, where the color bar describes the wind speed magnitude. Fig.2(b) shows the wind direction during 14 hours on December 4, 2005. The wind direction changes from north below 1km to north-west above about 1km.



(a) wind velocity



(b) wind direction

Fig. 2. Continuous wind observation in 3 days

4. CONCLUSIONS

The 1.06μm aerosol Doppler lidar built at Hefei has probed the low troposphere wind profiles routinely. Comparison of wind vector between the lidar and the meteorological radar shows a good agreement, and the lidar will be used for the local meteorological research.

5. REFERENCES

1. Sun D., Zhou J., and Hu H., “Wind lidar development at Hefei of China,” 22nd International Laser Radar Conference (22nd ILRC), 12-16 July 2004, Matera, Italy, 119-122(ESA SP-561, June 2004).

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