S4-4 Incoherent Doppler lidar controlling actively the laser wavelength

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1. Introduction

The observations of the wind structure from the ground to the stratosphere are important for a weather forecast and prediction of global climate change. Korb et al. proposed the double edge technique[1-2] using two etalon filters for an incoherent wind Doppler lidar. In this technique, Doppler shift component is measured from the change of the transmitted signal through the each filter. This method is necessary to control accurately the spectra of two filters and the laser frequency to achieve the high accuracy for wind measurement. Subsequently, Friedman et al. proposed the edge technique that used an iodine vapor filter instead of the etalon for measurement of the upper atmospheric wind[3].

We present a new incoherent Doppler lidar using two transmission slopes of one iodine absorption line and the injection seeded Nd:YAG laser (532nm) that changes the frequency alternately[4-5]. The laser located at the midpoint of one edge is made to shift alternately to the midpoint of another edge using the AO wavelength shifters, and the signals that pass through the two edges are synchronously received. The Doppler shift component is obtained from the change of the two signals.

In the next stage, we plan the Doppler lidar of 355nm that is the eye safe wavelength using the etalon filter. However, frequency controls of the laser and the filter in the MHz order are needed in order to measure with the high accuracy. Then, we also propose the method that the laser follows the drift of the edge transmission caused by the temperature change.

In this paper, we show the result of the wind measurement experiment using the iodine vapor filter and the method to control the etalon and the laser in the ultraviolet region.

2. Wind measurement using iodine vapor filter

Transmission curve of the iodine vapor filter and the spectra of the signal scattered from atmosphere are shown in Fig.1 and the block diagram of our Doppler lidar system is shown in Fig.2. We transmit alternately the pulse laser locked to the midpoint of either one edge (ν1) or another edge (ν2) using the AO wavelength shifter. Thus, the shift frequency Δνs is |ν1-ν2|. The Doppler shift component Δνd is obtained from the change of the two signals at ν1 and ν2 received alternately.

We obtain the preliminary result of the wind measurement experiment using this lidar system.

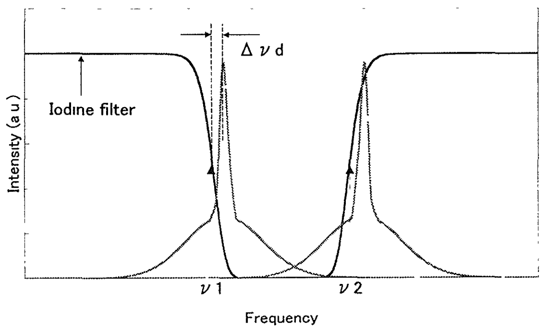

Fig.1 The relation of transmission curve of the iodine vapor filter and the spectra of the signal scattered from atmosphere.

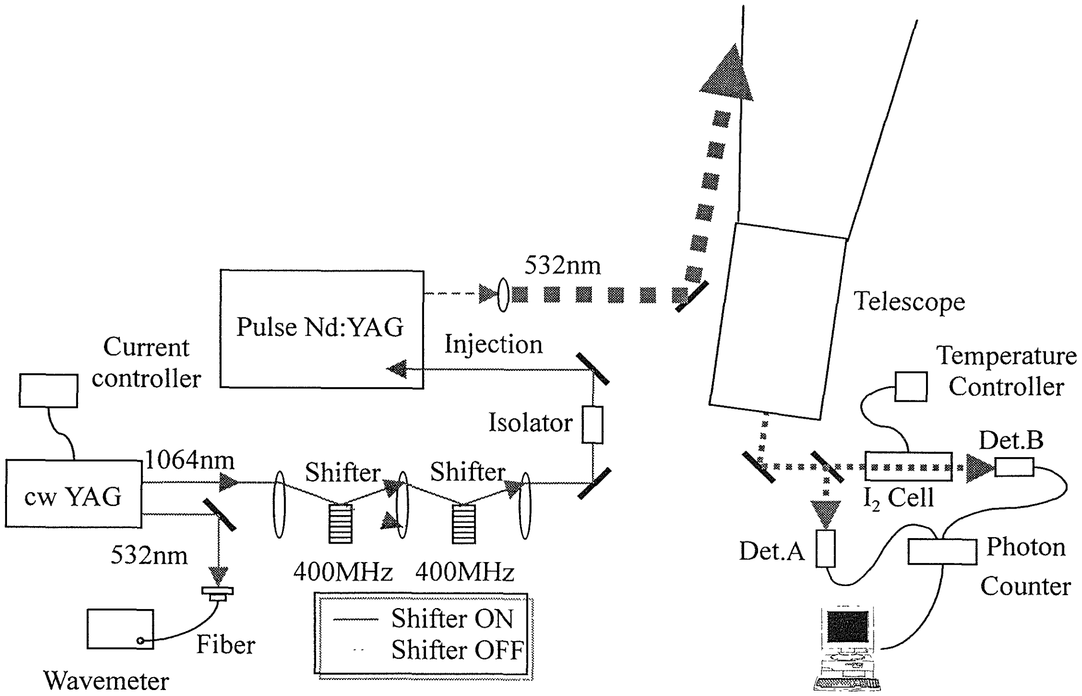

Fig.2 Outline of the new edge technique using the iodine vapor filter and AO wavelength shifters.

The transmitter is a pulsed Nd:YAG laser (532nm) and is injection seeded by a cw diode-laser pumped Nd:YAG laser that has both 1064 and 532nm output. We lock the frequency of the double seeder output to the 50% absorption point on the edge of the iodine absorption line 1106 and monitor the wavelength of the double seeder output with the wavemeter of 0.1pm accuracy. Two AO shifters (400MHz × 2) connected in series can change the frequency of the fundamental seeder output. To maintain the filter shape, we control the iodine cell temperature. The backscattering signal is received by the telescope and splitted into two paths. One light beam is received directly by the PMT (Det.A) that is energy monitor channel and the other beam is received through the iodine cell by the PMT (Det.B).

We measured alternately with two frequencies. Lidar system parameters are shown in Table 1. Fig.3 shows the lidar wind profile and two radiosonde wind profiles that are observed at the close time to the lidar measurement (April 13, 1999 at 21:00 and April 14, 1999 at 9:00). These radiosonde data were observed at Tateno away about 80km from our lidar site. The lidar measurement time for one profile is 30 minutes.

The advantage of this system is that the wavelength is accurately changed using the AO wavelength shifter and the filter is treated easily, because we use only one filter. And, the temperature stability of the iodine filter is better considerably than that of the etalon filter.

Table 1 Lidar system parameters

Wavelength	532nm
Pulse energy	100mJ
Telescope diameter	35cm
Zenith angle	15deg.
Range resolution	500m
Total shot number	54000×2 (ν1,ν2)
Δνs	800MHz
I_2 cell length	20cm

Though we use the iodine vapor filter in this method, it is also possible to use other filters; an etalon, atomic filters such as the sodium, the potassium and so on.

3. Eye safe lidar system

We examine the application of this system using the etalon filter for 355nm, THG of the Nd:YAG

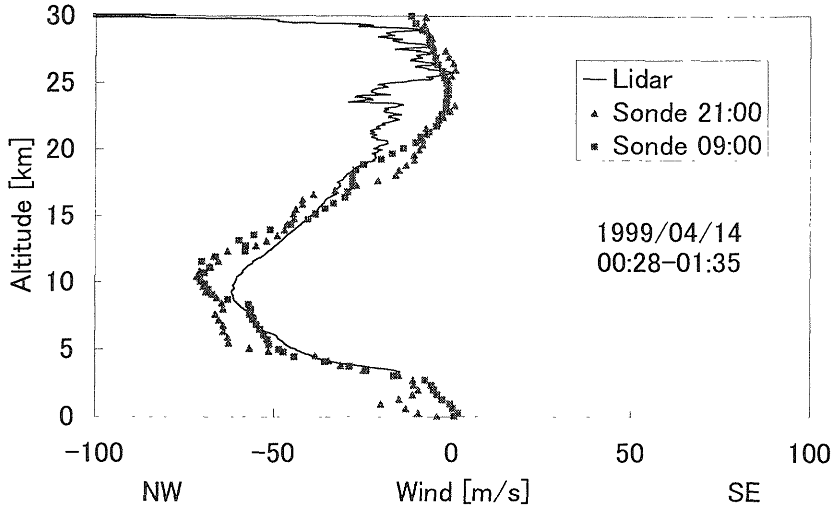

Fig.3 The lidar wind profile using the iodine edge filter compared with the radiosonde wind profiles observed at a distance of about 80km from our lidar site.

laser, that is the eye safe wavelength. In the etalon edge technique, the frequency control of the laser and the filter is necessary in the MHz order to measure with the high accuracy. We use the solid etalon that is easy treatment and low cost comparing with the air space etalon. However, the thermal expansion of the solid etalon that has a comparatively small coefficient is about 10 GHz/℃.

In order to reduce the instability of the solid etalon, we propose the methods that we monitor the drift of the edge and that the laser follows the drift of the edge. The system figure is shown in Fig.4. A small fraction of the laser signal is picked off from the outgoing beam. This signal is guided for the system of the signal receiver of Fig.2. We control the location of the laser to lock the midpoint of the edge from the change of the filter transmission signal. We can almost ignore the drift of the edge filter by applying this system to the Doppler lidar.

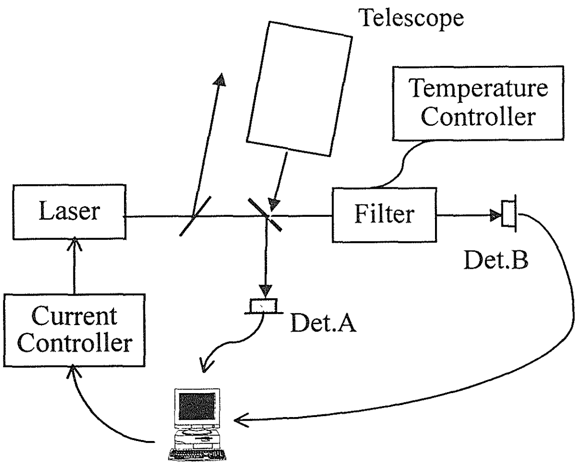

Fig.4 Outline of the laser and the etalon control system.

4. Summary

We propose the new edge technique using two transmission slopes of one filter as. The laser frequency located at the midpoint of one edge is made to shift to the midpoint of another edge using the AO wavelength shifters every laser shot. The Doppler shift component is obtained from the change of two signals passed through the edge filter. We obtain the preliminary results of the wind measurement experiment using the iodine vapor filter at 532nm. Afterward, for the Doppler lidar using 355nm that is the eye safe wavelength is developed, and we use the solid etalon filter instead of the iodine filter. In order to reduce the influence of the frequency instability of the edge filter, we monitor the laser beam passed through the filter and control the laser frequency as following to the temperature drift of the edge.

Reference

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