MULTIWAVELENGTH AND DEPOLARIZATION LIDAR MEASUREMENTS OF CLOUDS AND AEROSOLS

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ABSTRACT

We report lidar observations of wildfire smoke and clouds that were made with two lidar systems in August 2005 in Interior Alaska. One lidar system was a single channel eye-safe lidar system operating at 1574 nm. The other lidar system was a 10-channel system operating with depolarization and Raman capabilities at 532 nm and backscatter at 1064 nm. We will provide a characterization of the smoke and clouds and compare these measurements to the lidar measurements made during the FROSTFIRE experiment in 1999.

1. INTRODUCTION

This paper presents multi-wavelength lidar observations of tropospheric aerosols and clouds at Chatanika, Alaska (65°N, 147°W) on the night of 18-19 August 2005. The lidar observations were made with two lidar systems; the National Institute of Information and Communications Technology (NICT) Multi-Wavelength Lidar (MWL) and the Geophysical Institute of the University of Alaska Fairbanks (GI-UAF) Compact Eye-Safe Backscatter Lidar (CESBL) systems. The lidar observations were made at Poker Flat Research Range (PFRR) while a significant number of wildfires were burning across the interior of Alaska. The wildfire smoke was noted by on-site observers. The lidar measurements detected both smoke associated with the wildfires as well as clouds in the mid-troposphere. Our goal is to analyze the cloud and aerosol characteristics and compare the results with lidar measurements made during the FROSTFIRE experiment in 1999 [1].

2. EXPERIMENT

The lidar systems were operated in the Lidar Research Laboratory (LRL) at PFRR. The LRL is located 394 m above sea level. The NICT-MWL is an extension of a Rayleigh lidar that was deployed at PFRR in November 1997 [2]. The NICT-MWL employs the same Nd:YAG transmitter as the Rayleigh lidar and a 10-channel receiver system (Table 1). The receiver uses three telescopes that are positioned with respect to the transmitting laser to allow measurements at different sensitivities over different altitude ranges. Channel 1 employs a dedicated small telescope and measures haze in the boundary layer and has an overlap with the transmitted lidar beam at 150 m. Channels 2 through 6 employ a Celestron-14 telescope and make measurements in the troposphere from 800 m upward. Channels 7 through 10 employ a Celestron-14 telescope and make measurements in the troposphere and stratosphere from 4 km upward. Channel 7 employs a silicon diode to detect elastic backscatter from the transmitted 1064 nm laser beam. The other nine channels employ photo-multiplier tubes to detect light scattered by the transmitted 532 nm beam. Each channel has a dedicated multi-channel scalar unit that operates in photon-counting mode. Channels 5 and 6 detect parallel polarized light from the troposphere with different sensitivities by splitting the backscattered light 20% (Channel 5) and 80% (Channel 6). Channels 9 and 10 detect parallel polarized light from the troposphere with different sensitivities by splitting the backscattered light 20% (Channel 9) and 80% (Channel 10). The raw lidar profiles represent the integration of 1000 individual lidar echoes collected over 50 s at a resolution of 12 m.

Table 1. NICT MWL

Channel No.	Channel Description	Overlap Altitude
1	Elastic backscatter at 532 nm	150 m
2	Raman backscatter at 660 nm	800 m
3	Raman backscatter at 607 nm	800 m
4	S polarization backscatter at 532 nm	800 m
5	P polarization backscatter at 532 nm at 20%	800 m
6	P polarization backscatter at 532 nm at 80%	800 m
7	Backscatter at 1064 nm	4000 m
8	S polarization backscatter at 532 nm	4000 m
9	P polarization backscatter at 532 nm at 20%	4000 m
10	P polarization backscatter at 532 nm at 80%.	4000 m

The CEBSL is a single channel eye-safe backscatter lidar that operates at 1574 nm [3, 4]. The transmitter is an Nd:YAG laser operating at 1064 nm that uses an OPO to generate the 1574 nm light. The receiver employs an InGaAs photodiode and high-speed digitizer that records the backscatter profile. The raw lidar profiles represent the integration of 512 individual lidar echoes collected over 51 s at a resolution of 1.5 m.

3. OBSERVATIONS

The MWL began observations at 2233 AST (= UT-9 h) and continued until 0434 AST. The CESBL began observations at 2246 AST and continued until 0457 AST. The lidar signals early in the observation period are shown in Fig. 1. The CESBL detects enhanced Mie scattering due to smoke in the lower troposphere (up to ~1.5 km above ground level) and a cloud (between 4 and 5 km with a peak near 4.5 km) (Fig. 1a). The MWL also detects enhanced Mie scattering in both s- and p- polarization in the lower and middle troposphere in Channels 4 and 5 (Fig. 1b). The MWL detects the Mie scattering from the cloud in both s- and p- polarization at higher sensitivity in Channels 8 and 9 (Fig. 1c). The MWL also detects the Mie scattering from the cloud at 1064 nm in Channel 7 (Fig 1d).

4. DISCUSSION AND SUMMARY

These lidar observations allow the characterization of the wildfire smoke at two wavelengths (532 nm and 1574 nm) and at two polarizations and characterization of the cloud layer at three wavelengths and two polarizations (532 nm, 1064 nm, and 1574 nm) as well as two polarizations. A complete analysis of the lidar measurements (that uses the Raman, depolarization and multi-wavelength signals) will be conducted to determine the scattering and physical properties of the smoke and clouds. The results will be compared with the results of the FROSTFIRE experiment.

5. References

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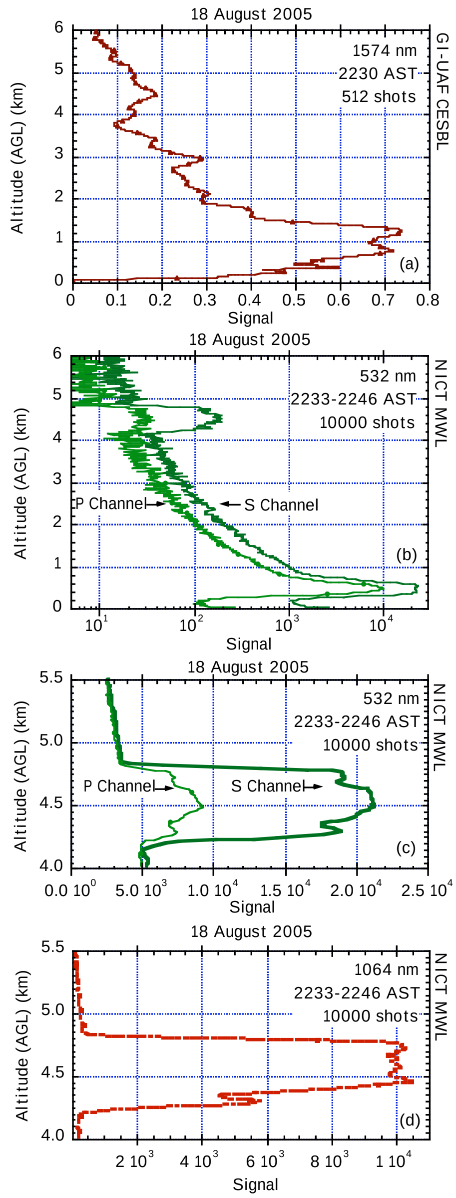

Fig 1. Integrated lidar signals plotted as a function of altitude above ground level. (a) Signal measured by CESBL at 1574 nm. (b) Signal measured by MWL in Channel 4 (s-polarization) and Channel 5 (p-polarization) at 532 nm. (c) Signal measured by MWL in Channel 8 (s-polarization) and Channel 9 (p-polarization) at 532 nm. (d) Signal measured by MWL in Channel 7 at 1064 nm.

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