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THE USE OF AN AIRBORNE LIDAR FOR MAPPING CIRRUS CLOUDS IN FIRE PHASE II

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The University of Washington and Georgia Tech have recently built a dual-wavelength airborne lidar for operation on the University of Washington's Convair C-131A research aircraft. This lidar has been used successfully in studying aerosols and clouds. These studies have demonstrated the utility of airborne lidar in a variety of atmospheric research and prompt our suggestion that this facility be included in the next FIRE cirrus experiment.

The vertically-pointing airborne lidar would be used as a complement to ground-based lidars. The airborne lidar would ensure extended coverage of IFO cases that develop upwind of the surface lidars or which miss the ground-based lidars while still being the focus of satellite and aircraft in situ studies. The airborne lidar would help assure that cirrus clouds were simultaneously viewed by satellite, sampled by aircraft, and structurally characterized by lidar.

Table 1 lists system specifications and Figure 1 shows a schematic of the lidar system aboard the C-131A. Polarized, incoherent, monochromatic light is emitted from the neodymium-doped ytrrium aluminum garnet (Nd:YAG) laser simultaneously at both the primary (1.064 μm) and frequency-doubled (0.532 μm) wavelengths. The beam is reflected by a mirror 90° toward the center line of the telescope assembly. The beam is then reflected by another mirror and is emitted upward along the axis of the telescope. Alignment of the laser beam with the telescope is controlled by adjusting the second mirror. The emitted laser pulse, which has a pulse width of 20 ns (or 6 m) and energies of 70 mJ at 1.064 μm and 45 mJ at 0.532 μm, travels upward while diverging at an angle of approximately 1 mrad. The laser pulse interacts with gas molecules, aerosol and cloud particles, returning a small fraction of the energy as backscattered light at the same wavelengths. This return pulse is received and focused by the 0.356 m (14 in.) Cassegrainian telescope.

After the light passes through the telescope, it strikes a dichroic mirror. This beamsplitting device allows the infrared wavelength to pass without reflection; the visible light is reflected 90°. The 1.064 μm beam is detected by as silicon avalanche photodiode (APD), while the visible light is sensed with a photomultiplier tube

TABLE 1

THE UNIVERSITY OF WASHINGTON-GEORGIA TECH LIDAR SYSTEM

Specifications

A) Laser

Type: Neodynium-doped Yttrium Aluminum Garnet (Nd-YAG)
Wavelengths: 1.064 and 0.532 μm
Energies: 70 and 45 mJ
Pulse width: 20 ns
Beam divergence: 1 mrad

B) Telescope

Type: Cassegrainian
Diameter: 0.356m (14 in)

C) Detection

Polarizing filters: selectable for parallel and perpendicular polarizations
Detectors: 1.064 μm
Type: Silicon Avalanche Photodiode
0.532 μm
Type: Photomultiplier tube

D) Data acquisition/control system

Data input and shot summing
Type: CAMAC crate
Manufacturer: DSP Technologies, Inc.
Digitization rate: 50 ns

Control/display computer: 20 MHz AT-compatible microcomputer
Data display: VGA monitor, 640 x 480 resolution
Data storage: 80 megabyte hard disk and
2.2 gigabyte mini-video cassettes

A schematic of the lidar system is shown in Fig. 1

(PMT). The signals from each of these detectors pass through separate pre-amplifiers (to convert current to voltage) and logarithmic amplifiers. The logarithmic amplifiers are needed to detect a wide range of signal strengths without electronic saturation.

The amplifier outputs are received by a data acquisition system (DAS, DSP Technologies, Inc.), which has a variable signal digitization rate of 25 or 50 ns, corresponding to vertical resolutions of 7.5 and 15 m, respectively. The data are summed in the DAS for a user-specified number of laser shots, and are then dumped to an IBM clone 20 Mz/80386 AT microcomputer through an input board supplied with the DAS. An Exabyte 8mm cartridge tape (2.1 gigabyte) recorder is used to log the data. The microcomputer also displays both wavelengths in a false color vertical cross-section (at half resolution) in real-time aboard the aircraft. As an example we show in Fig. 2 a gray-scale depiction of thin altostratus clouds some 4-6 km above the lidar and higher and rather complex cirrus clouds near the tropopause. Despite modest transmitted energies, the lidar has demonstrated more than sufficient sensitivity for cirrus measurements in a full daylight environment.

With the lidar's laser aboard the C-131A aircraft pulsing at 20 Hz (maximum rate), we can achieve a horizontal resolution of 4 m and a vertical resolution of 7.5 m (at a maximum range of 7.5 km) or 15 m (at a maximum range of 15 km). The aircraft would have a mission endurance of ~7 hr at a flight elevation of 3 km MSL.

This lidar, combined with the aircraft's radiometric and cloud physics instrumentation, as well as a vertically-pointing (up or down) 8.6 mm radar, would be of significant utility in FIRE Phase II.

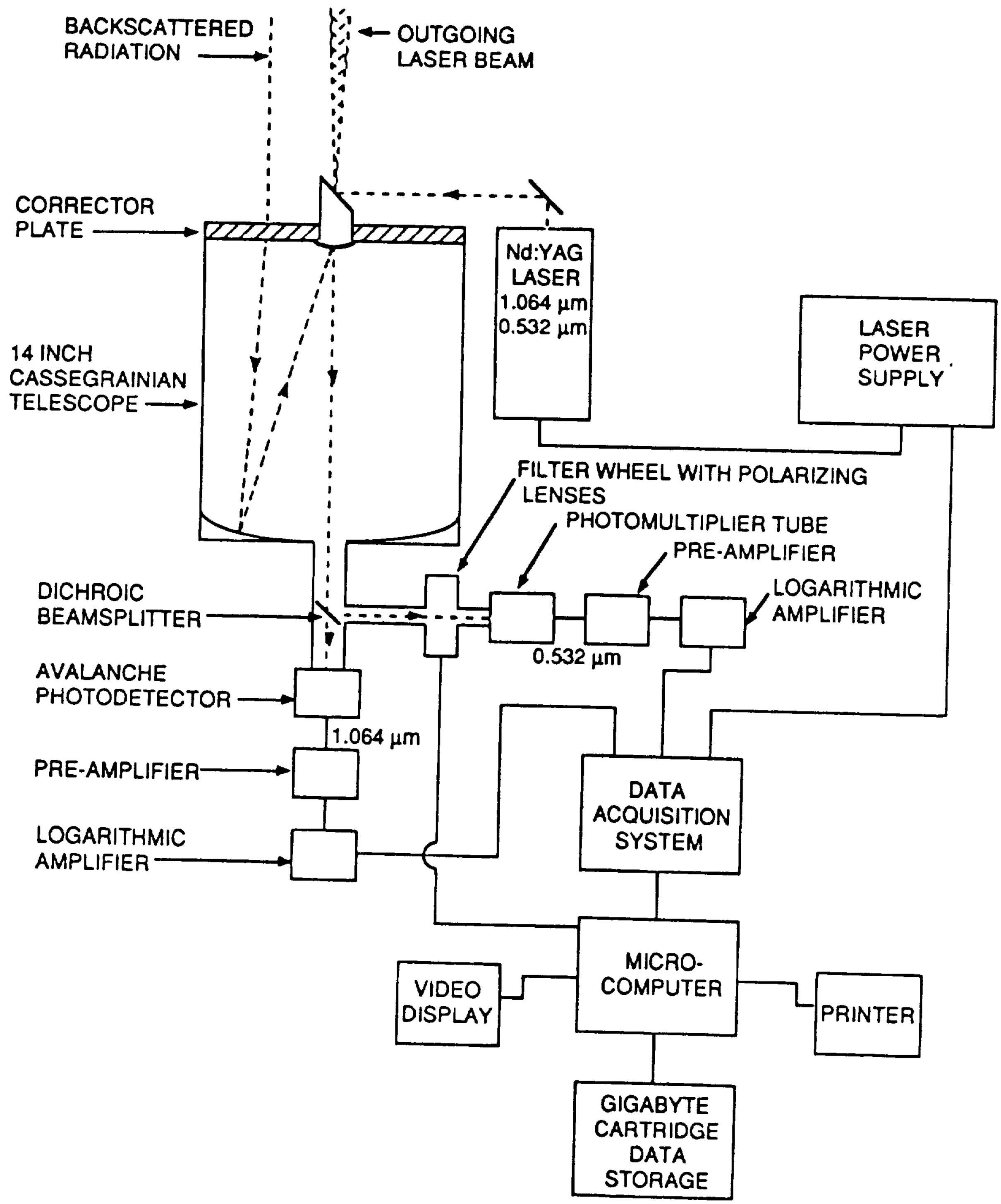

Figure 1. Schematic of the University of Washington-Georgia Tech Lidar System aboard the University of Washington's Convair C-131A aircraft.

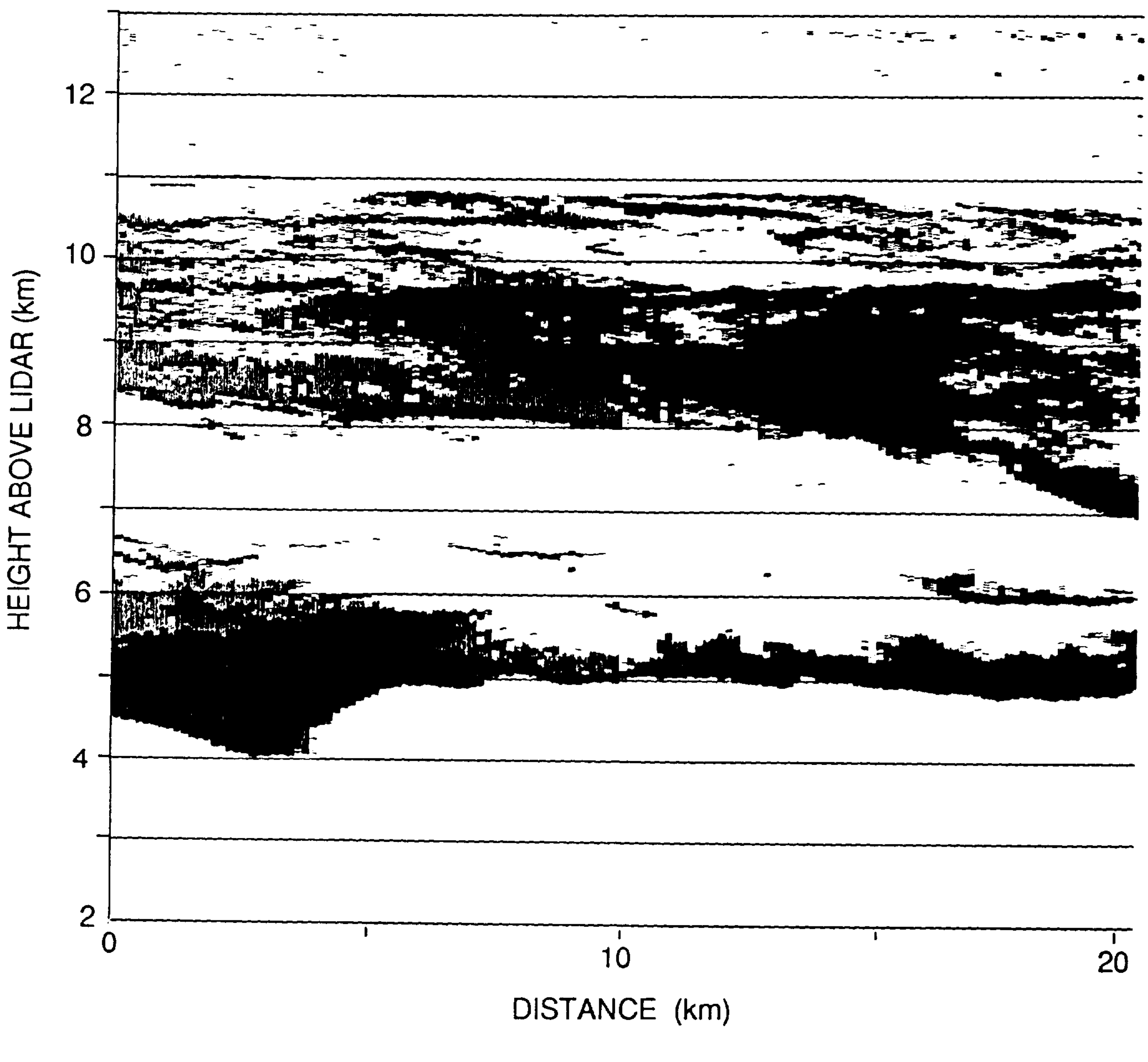

Figure 2. Lidar backscatter cross-section (at $\lambda = 1.06\ \mu m$) of altostratus and cirrus clouds obtained with the lidar aboard the University of Washington's Convair C-131A research aircraft.