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THE NCAR AIRBORNE INFRARED LIDAR SYSTEM (NAILS)

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Purpose. This paper presents a planned airborne lidar system, which is intended to provide the university atmospheric science research community with a remote sensing facility for a variety of applications. The eventual goal of the system development is a Doppler wind measurement capability for boundary layer dynamics and cloud physics applications, among others. However, the first stage of development (and this presentation) is focused initially on a direct-detection lidar to measure aerosol profiles and depolarization from cloud backscatter. Because of the Doppler goal, interest in larger particles to define the top of the mixed layer, and eye safety, the first stage of the system is based on a pulsed CO_2 laser.

Our philosophy emphasizes a compact, relatively simple and inexpensive system that achieves flexibility to meet the data requirements of a variety of investigators by being easily modified rather than having many different capabilities built in. Although the direct-detection sensitivity is less than that for heterodyne detection, the simpler system allows us to obtain useful scientific results and operating experience toward more complex lidars while staying within budget and time constraints. Initial tests of the system in a downlooking mode are planned for a King Air twin-turboprop aircraft.

Relation to previous work. NAILS represents an evolution from previous work, not a revolutionary step. Steinvall et al. (1983) used a direct-detection lidar, based on a pulsed CO_2 laser, for ground-based aerosol profile measurements to approximately 1-km altitude, and Uthe (1981) mentioned the use of a ground-based lidar using a CO_2 laser and direct detection. In contrast to the ground-based systems, Itabe et al. (1984) reported on a direct-detection CO_2 lidar for a small aircraft, and Bilbro et al. (1984) have been flying a heterodyne Doppler lidar in a large aircraft for a number of years. Participants in the conference are well aware of less directly related CO_2 lidars involving ground-based Doppler systems and airborne CW Doppler lidars.

We calculate a signal-to-noise ratio of approximately one at a range of 1 km for a backscatter coefficient of 5×10^{-9} $m^{-1}\ sr^{-1}$ for a single pulse from a lidar with the parameters mentioned below. This is consistent with the observations of Steinvall et al. (1983), and emphasizes the necessity for signal averaging with a direct-detection infrared lidar.

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Design details. NAILS uses a Dall-Kirkham telescope as a transceiver. The Dall-Kirkham layout will permit repackaging the system in an external pod with minimum frontal area as an external store on the aircraft. Use of a common transmit and receive aperture minimizes the angular field, and therefore detector size and noise, gives geometrical compression of the dynamic range of the return (Harms et al., 1978), and allows later heterodyne operation. Transceiver operation will probably require considerable development to reduce parasitic scattering.

Some of the parameter values are listed below:

Laser: LSI 150G. 300 mJ at 50 Hz multimode, 130 ns pulsewidth, 210 mJ TEM_{00}, 150 Hz max, separable head and power supply

Transceiver: 30 cm, f/3 Dall-Kirkham

Detector: HgCdTe, 0.25 mm Ø

Digitizer: logamp to Tek 2430, 8 bits with on-board averaging

For aerosol profiling, the transceiver operates with a quarter wave plate and polarizing beam splitter as a beam switch. To reduce parasitic scattering, the phase retarder is the last element before the telescope secondary, and to reduce cost for the 50-mm beam, the element is a reflective phase retarder. For cloud depolarization measurements, the polarizing beam splitter separates parallel and cross polarization components, and we accept the loss of 6 dB involved in using a 50% beam splitter as a transmit-receive beam switch rather than sacrifice the transceiver arrangement.

Status. First ground tests are planned for summer, 1986. If the system debugging goes well, we could perform flight tests in September 1986, with first scientific applications in spring 1987. One early application could be to study the structure of the top of the boundary layer, analogous to the research of Melfi et al. (1985). Because the CO_2 lidar is sensitive to larger particles than a short-wavelength lidar is, it may give a different perspective on the thickness of the mixed layer.

The next step, after downlooking tests and field application, is to install NAILS for viewing in other directions. The next stage in system development is to increase the sensitivity by using heterodyne detection without trying to stabilize the laser frequency better than is required for a reasonable intermediate-frequency filter.

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