N87-10282

AIRBORNE LIDAR MEASUREMENTS OF THE ATMOSPHERIC PRESSURE PROFILE WITH TUNABLE ALEXANDRITE LASERS

C. L. Korb, G. K. Schwemmer, M. Dombrowski, J. Milrod, and H. Walden, NASA Goddard Space Flight Center, Laboratory for Atmospheres, Greenbelt, Maryland, U.S.A

This paper describes the first remote measurements of the atmospheric pressure profile made from an airborne platform. The measurements utilize a differential absorption lidar and tunable solid state Alexandrite lasers. The pressure measurement technique[1] uses a high resolution measurement of the integrated path absorption in the wings of lines in the oxygen A band where the absorption is highly pressure sensitive due to collision broadening. We use absorption troughs, regions of minimum absorption between pairs of strongly absorbing lines, for these measurements. The trough technique allows the measurements to be greatly desensitized to the effects of laser frequency instabilities.

Our aircraft lidar system incorporates two Alexandrite lasers which are continuously tunable from 725 to 790 nm and have a bandwidth of 0.02 cm^{-1} using a birefringent filter and two etalons. We have measured the short-term frequency stability of the lasers to be better than 0.005 cm^{-1} and the Q-switched pulse length to be 100-130 nsec. One laser has a 100 mm x 5 mm diameter Alexandrite rod and a 150 mJ output energy. The tuning elements are electronically controlled and have a 3 cm^{-1} spectral scanning capability. The second Alexandrite laser has a 75 mm x 5 mm rod and a 100 mJ output energy. Its tuning elements are manually controlled and it is typically used for the off-line measurement. Both lasers operate at repetition rates up to 10 Hz and have a multi-mode spatial intensity distribution. The output of each laser consists of three axial modes with overall widths of 0.016 and 0.026 cm^{-1} for the two lasers, respectively. We have measured the spectral purity of the Alexandrite lasers to be greater than 99.99%.

The energy backscattered from the atmosphere is collected with a 40 cm telescope and detected with a multialkali photomultiplier tube. The receiver field of view was set at 8 mrad for the nighttime measurements and a 720 nm long pass filter was used for spectral background rejection. A 200 μsec time delay between the laser pulses was introduced to separate the on- and off-line laser signals. A single detector channel is used to observe both on- and off-line signal returns. The signals from the photomultiplier are digitized with 10 (flight 1) or 12 bit (flight 2) transient digitizers at 5 MHz. An LSI-11/23 microprocessor controls system functions, monitors operator inputs, and displays system status and data in real time.

The airborne measurements of the atmospheric pressure profile were made using the Goddard lidar facility on the Wallops Lockheed Electra aircraft. Flights were made on November 20 and December 9, 1985. Data for the first flight were taken along the flight line extending from Sea Isle, Delaware (39°05'N/74°45'W) to Point Lynus (38°01'N/72°39'W), approximately 220 km off the coast of Delaware. Data for the second flight were taken along the line between Sea Isle, Delaware, and Bowie, Maryland (39°00'N/76°44'W).

Figure 1 shows data from the November 20 flight taken near Point Lynus. The lidar system was set up to measure pressure with the on-line laser tuned to the absorption trough at 13147.3 cm^{-1} and with the reference laser tuned to a non-absorbing frequency near 13170.0 cm^{-1}. The lidar signal returns were sampled with a 200 nsec range gate (30 m vertical resolution) and

averaged over 100 shots. The integrated absorption coefficient between the lidar at the aircraft altitude of 2790 m and each altitude was calculated from these data. The pressure profile was then determined by relating the measured integrated absorption coefficient to the difference in the squares of the pressures at the measurement altitude and laser altitude.[1] Uncertainties in the oxygen line parameters were corrected for by a single constant calibration fit of the measured data to ground truth. Figure 1 shows a comparison of the lidar measured pressure profile in the vicinity of Point Lynus to radiosonde data taken two hours earlier at Wallops Island, Virginia (37°51'N/75°28'W). The average deviation of the lidar pressure profile data from the radiosonde data is less than 2.0 mb. As shown, the deviation between the lidar and radiosonde profiles tends to be systematic. We note that the noise level of the raw lidar data was close to the theoretical limits.

Reference

1. Korb, C. Laurence and Chi Y. Weng, "Differential Absorption Lidar Techniques for Measurement of the Atmospheric Pressure Profile," Applied Optics, 22, 3759-3770, 1983.

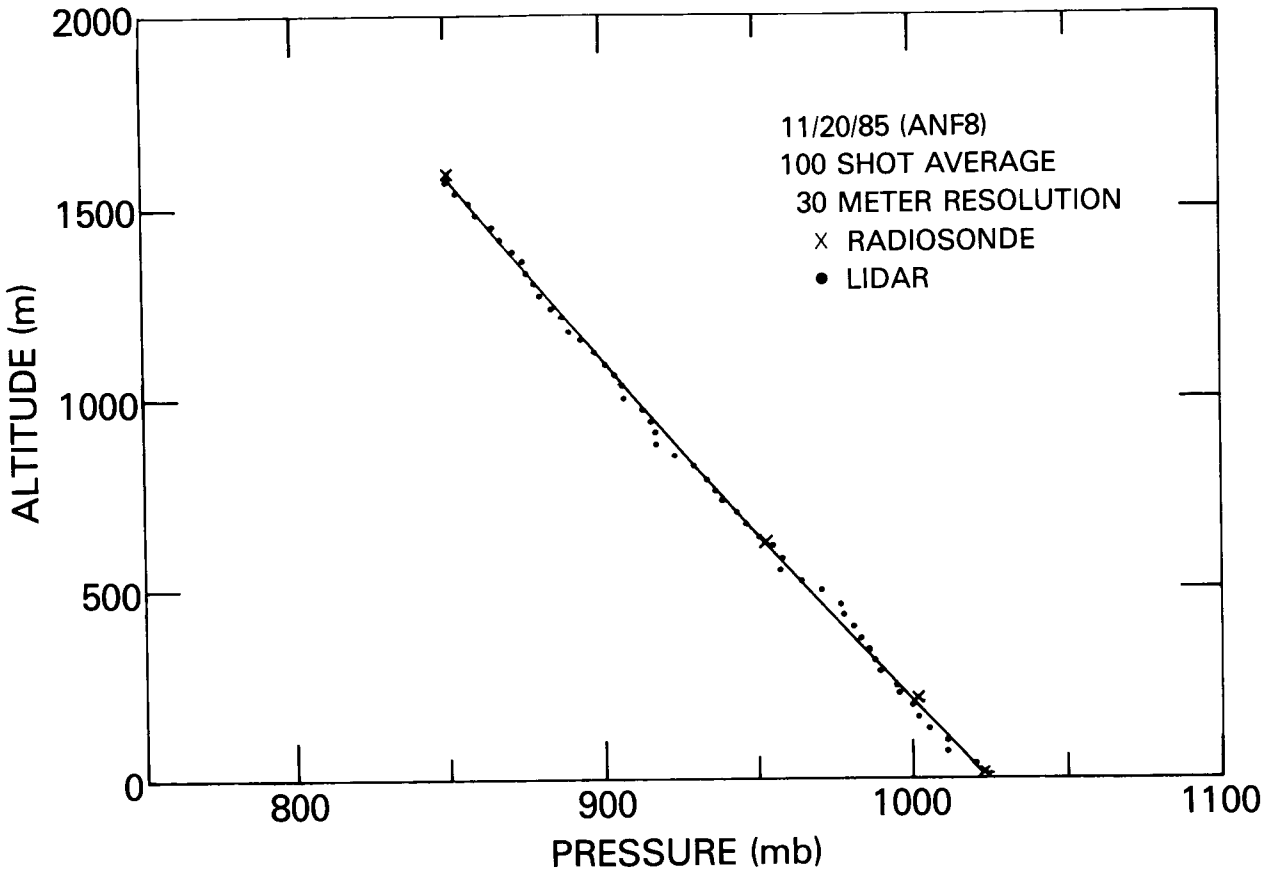

Figure 1 – Lidar pressure profile measured from aircraft at 2790m compared with radiosonde data.