REMOTE MEASUREMENT OF ATMOSPHERIC TEMPERATURES BY RAMAN LIDAR

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ABSTRACT

The Raman shifted return of a lidar, or optical radar, system has been utilized to make atmospheric temperature measurements. These measurements were made along a horizontal path at temperatures between $-20^{\circ}C$ and $+30^{\circ}C$ and at ranges of about 100 meters. The temperature data were acquired by recording the intensity ratio of two portions of the Raman spectrum which were simultaneously sampled from a preset range.

The lidar unit employed in this testing consisted of a 4 joule-10ppm laser operating at 694.3 nm, a 10-inch Schmidt-Cassegrain telescope, and a system of time-gated detection and signal processing electronics. The detection system processed three return signal wavelength intervals - two intervals along the rotational Raman scattered spectrum and one interval centered at the Rayleigh-Mie scattered wavelength. The wavelength intervals were resolved by using a pellicle beam splitter and three optical interference filters. Raman return samples were taken from one discrete range segment during each test shot and the signal intensities were displayed in digital format. The Rayleigh-Mie return was monitored continuously through standard oscilloscope display techniques.

The test site utilized to evaluate this measurement technique encompassed a total path length of 200 meters. Major components of the test site included a trailer-van housing the lidar unit, a controlled environment test zone, and a beam terminator. The control zone which was located about 100 meters from the trailer was 12 meters in length, 2.4 meters in diameter, and was equipped with hinged doors at each end. The temperature of the air inside the zone could be either raised or lowered with respect to ambient air through the use of

infrared heaters or a liquid-nitrogen cooling system. Conditions inside the zone were continuously monitored with a thermocouple rake assembly. The test path length was terminated by a 1.2 meter square array of energy absorbing cones and a flat black screen.

Tests were initially conducted at strictly ambient conditions utilizing the normal outside air temperatures as a test parameter. These tests provided a calibration of the Raman intensity ratio as a function of temperature for the particular optical-filter arrangement used in this system while also providing a test of the theoretical prediction formulated in the design of the system. Later tests utilized zone temperatures above and below ambient to provide temperature gradient data. These tests indicate that ten shots, or one minute of data acquisition, from a 100 meter range can provide absolute temperature measurements with an accuracy of $\pm$ 3°C and a range resolution of about 5 meters. Because this measurement accuracy compares well with that predicted for this particular unit, it is suggested that a field-application system could be built with significant improvements in both absolute accuracy and range.