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LIDAR OBSERVATIONS OF POLAR STRATOSPHERIC CLOUDS AT McMURDO, ANTARCTICA, DURING NOZE-2

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SRI International operated a dual wavelength (1.064 μm and .532 μm) aerosol lidar at McMurdo Station, Antarctica, as part of the National Ozone Expedition-2 (NOZE-2). The objective of the project was to map the vertical distributions of polar stratospheric clouds (PSCs), which are believed to play an important role in the destruction of ozone in the Antarctic spring. Altitude, thickness, homogeneity, and duration of PSC events as well as information on particle shape, size or number density will be very useful in determining the exact role of PSCs in ozone destruction. The lidar gives a direct measure of PSC density distributions, and when combined with measurements of other investigators, additional properties of PSCs can be estimated.

Lidar data were collected on 22 days between September 3 and October 5, and PSCs were observed on 16 of those days. A total of over 200 hours of lidar data were collected. The lidar system transmitted energy into the atmosphere at an infrared wavelength of 1.064 μm (500 mj) and at a green wavelength of 0.532 μm (200 mj) simultaneously, with a pulse repetition frequency up to 10 pulses per second. The backscattered light was collected by a 61 cm diameter telescope, optically filtered to remove background light, separated into infrared and green components, and focused onto an appropriate detector. Three channels were used for data collection. The output of a silicon avalanche photodiode used for detection of the infrared (1.064 μm) signals was logarithmically amplified to enhance the dynamic range of the lidar observations, and then digitized by a high speed analog-to-digital (A-D) converter (12-bit, 10 MHz). An average of 128 laser firings (a 30 second to 5 minute time period) was then recorded on 9-track magnetic tape. The green lidar optical returns were converted to electrical signals by a photomultiplier tube. The high gain of the PM tube necessitated gating the tube to prevent detector saturation from strong lower tropospheric backscatter signals.

During NOZE-2, the PM tube was normally gated on at a lidar range of approximately 10 km. An analog signal was taken from the anode of the tube, logarithmically amplified and digitized with a high-speed averaging A-D converter (10 bit, 20 MHz). An average backscatter signature derived from 256 laser firings was then recorded on magnetic tape. The signal from the last dynode of the PM tube was used in a photon-counting data channel. Again, averages of 256 lidar signatures were written on the magnetic tape. Both A-D converters operated at a vertical resolution of 15 m, while the photon counter provided a vertical resolution of 150 m. A color display of all three signals was used for real-time monitoring of the lidar performance and for providing information on aerosol distributions for operational purposes.

Figure 1 (presented here in black-and white) is an example of the real time display generated during data collection. The PM tube was gated on at about 10 km, and Rayleigh scattering can be seen in both the analog ("green") and in the photon counting channel ("blue") up to an altitude of 20 km. A PSC return feature is seen in both PM tube channels between 16 and 18 km. The 1.064 µm return signal ("red") shows Rayleigh scattering below 4 km and cirrus cloud backscatter between 4 and 8 km. No evidence of the PSCs is seen in the infrared return signal because of the reduced sensitivity of the infrared system.

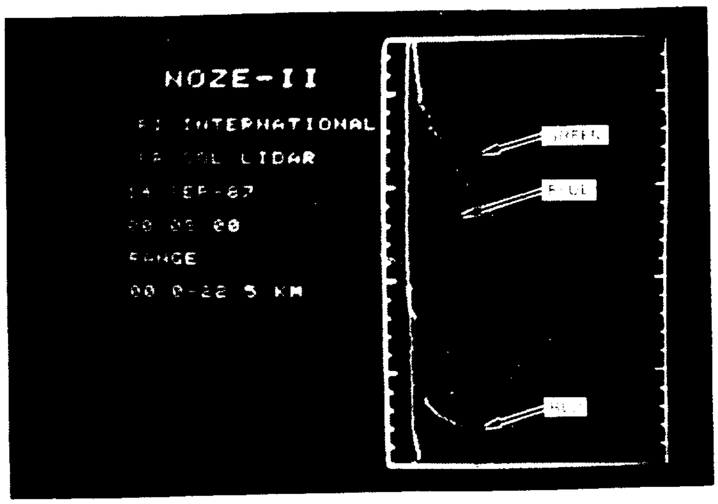

FIGURE 1 REAL-TIME DISPLAY WITH 1.064 µm RETURN (RED), 0.532 µm ANALOG RETURN (GREEN), AND 0.532 µm PHOTON COUNTING RETURN (BLUE)

Figure 2 is an example of PSC height/time distributions derived from 0.532 µm analog return signals displayed with a post-collection data processing program. The PSCs are seen as white bands between 12.5 and 14.5 km. The variability of the return signal strength and altitude is evident in this display. A short-lived layer of PSCs at 15.5 km centered at about 0100 local time is also of note.

The solid lines in Figure 3 represent an analysis of the photon counting signal in terms of relative backscatter (A) and scattering ratio (B) as functions of altitude. Scattering ratio is the total backscatter divided by Rayleigh backscatter, and is a parameter typically used to quantify lidar-detected stratospheric aerosol layers. The dashed line in (A) represents backscatter from a model Rayleigh atmosphere, and in (B) it represents the scattering ratio of a Rayleigh atmosphere (by definition equal to 1). The fine vertical structure seen in Figure 2 is not apparent in Figure 3 due to the 150 m range bins of the photon counting data channel.

More examples of PSC events will be presented in the formats of Figure 2 and Figure 3. Scattering ratios from the green analog data

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channel will be presented. Estimates of infrared scattering ratios will be shown for cases where PSCs were detected in the 1.06 μm channel. These results are currently being analyzed in terms of PSC properties which are useful for modeling the stratospheric ozone depletion mechanism.

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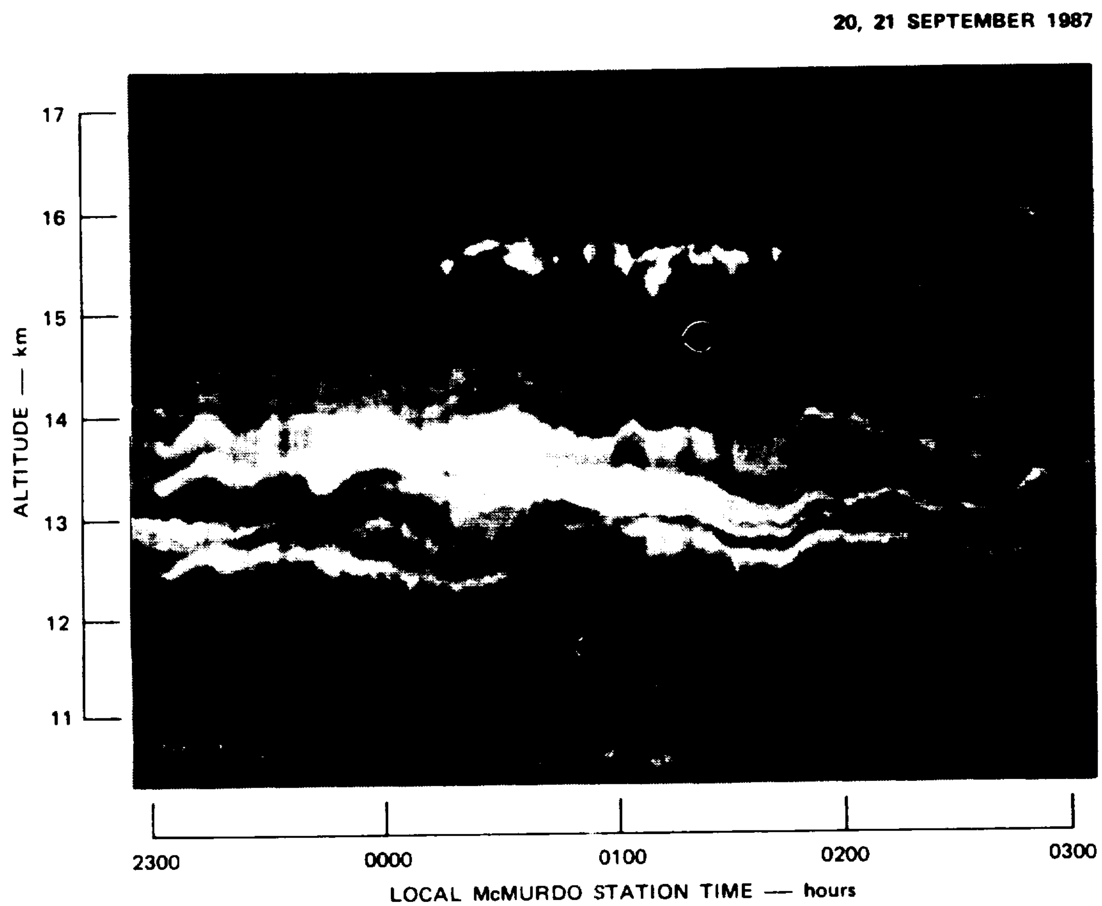

FIGURE 2 EXAMPLE OF HEIGHT/TIME POLAR STRATOSPHERE CLOUD STRUCTURE OBSERVED BY THE NOZE-2 LIDAR PROGRAM

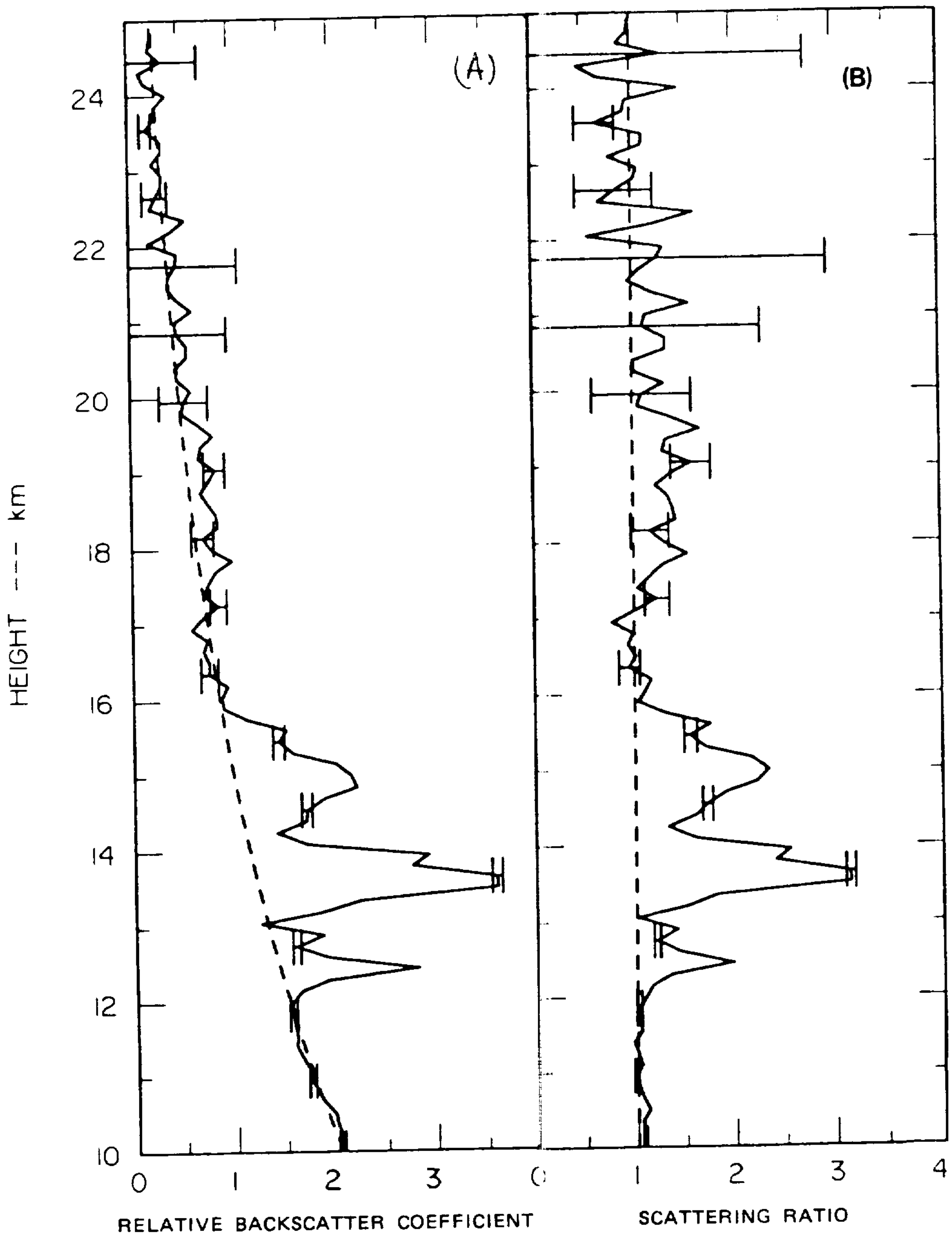

FIGURE 3 (A) LIDAR-MEASURED RELATIVE BACKSCATTER (SOLID LINE) AND RELATIVE RAYLEIGH MODEL BACKSCATTER (DASHED LINE), AND (B) LIDAR-MEASURED SCATTERING RATIO: McMURDO STATION, 21 SEPTEMBER 1987, 00300 LOCAL TIME.