NASA/CP-1998-207671/PT1

Nineteenth International Laser Radar Conference

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Abstracts of papers presented at a Conference sponsored by the National Aeronautics and Space Administration, Washington, D.C.; the United States Naval Academy, Annapolis, MD; the Naval Research Laboratory, Washington, D.C.; the Integrated Program Office, Silver Spring, MD; the Optical Society of America, Washington, D.C.; the American Meteorology Society, Boston, MA; the University of Maryland Baltimore County, Catonsville, MD; and Hampton University, Hampton, VA, and held at the United States Naval Academy, Annapolis, Maryland
July 6–10, 1998

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

July 1998

OPTICAL EXTINCTION IN CLOUDS AT MULTIPLE WAVELENGTHS

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SUMMARY

The Lidar Atmospheric Profile Sensor (LAPS) developed at Penn State University is used to measure the total atmospheric extinction coefficient at 284 nm, 530 nm, and 607 nm during the Southern California Ozone Study (SCOS). Extinction data at these wavelengths are presented during the development of a low-level cloud. While greater extinction at the ultra-violet (UV) wavelength is observed below the cloud (because of larger contributions of molecular Rayleigh scattering, small particle aerosol scattering and ozone absorption), the visible extinction becomes comparable to the UV extinction at cloud base. A time series of the visible extinction as the cloud grows is presented.

EXTINCTION RETRIEVAL

LAPS is a multi-wavelength Raman lidar with excitation wavelengths at 532 nm and 266 nm. The LAPS extinction retrieval technique has been described elsewhere (1), but we summarize it here. First, the Raman-shifted signals are range corrected and extinction at 530 nm is obtained with a least-squares fit of Beer's law compared to the expected gradient of the molecular profile. (The portion of the profile used for this analysis is beyond the region affected by the telescope form factor, or beyond about 800m). It is possible to assume that extinction coefficients at 530 nm (backscatter signal) and 532 nm (forward propagation) are nearly identical. Once the extinction at 530 nm is obtained it may be used to compute the attenuation of the forward beam, enabling the computation of the extinction of the return beam at the N_2 Raman-shift at 607 nm.

RESULTS

This paper presents extinction measurements of a cloud obtained during the Southern California Ozone Study (SCOS). Figure 1 shows a time sequence of the 530 nm extinction coefficient during the growth phase of a cloud. Lighter areas represent greater extinction coefficients than darker areas. The total optical depth between 2.3 km and 5 km at the

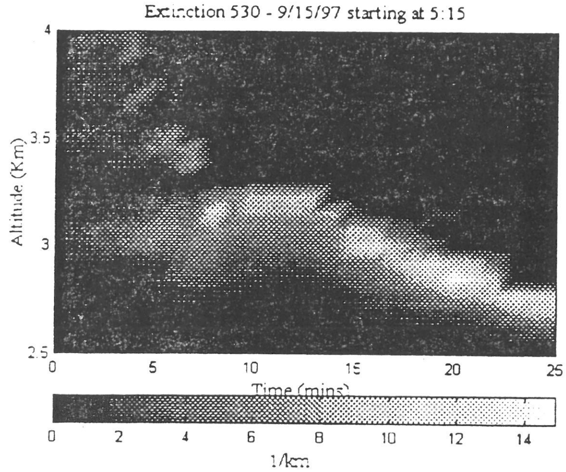

Figure 1 - Time series of extinction coefficient (km^{-1}) at 530 nm.

beginning of this time period indicated that a thick cloud was already present. (Note that the LAPS system is capable of penetrating optically thick clouds.) This cloud subsequently grows optically thicker and the cloud base decreases in altitude, as evidenced by the region of increased extinction in Figure 1. The dark region above cloud base after about 5:22 am (7 minutes into the sequence) is an area that was impenetrable by the lidar, and no information is retrieved beyond the indicated altitude.

A plot of multiple wavelength extinction coefficients averaged during the first 15 minutes of the same time period is shown in Figure 2. Ultra-violet extinction is greater than visible extinction below the cloud because of greater molecular Rayleigh scattering and ozone absorption. Scattering near the cloud base becomes more spectrally flat as cloud drops grow larger than both wavelengths. Probing further into the cloud reveals equal extinction at the red wavelength compared with the UV wavelength, consistent with expectations from Mie theory for spherical scatterers large compared with the wavelength.

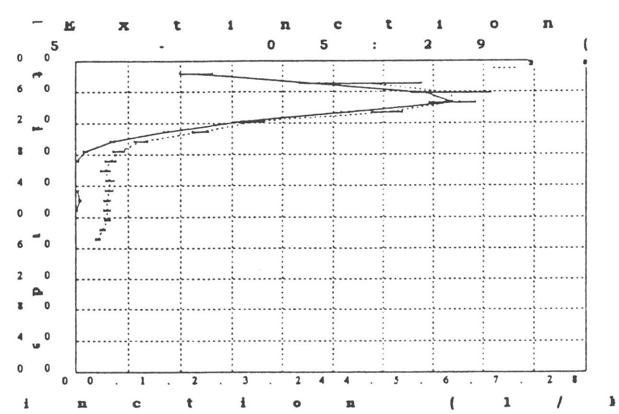

Figure 2 -- 284 nm and 530 nm extinction coefficients averaged for 15 minutes at 5:15 am.

ACKNOWLEDGEMENTS

Special appreciation for the support of this work go to SPAWAR PMW-185, California Air Resources Board (CARB), US Marine Corp at 29 Palms, the Mojave Desert Air Quality Management District, and the US EPA Monitoring Methods Research (Sect 8215). The efforts D.B. Lysak, Jr., T. Petach and Mike Zugger have contributed much to the success of the project. Conversations with Prof. Hans Verlinde of the P.S.U. Meteorology Department are also greatly appreciated.

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