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MOBILE LIDAR SYSTEM FOR MEASUREMENT OF WATER VAPOR MIXING RATIO AND OZONE NUMBER DENSITY

by

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The Code 674 Water Vapor Lidar has been modified and extended by Codes 674 and 617 to make differential absorption measurements of ozone. The Water Vapor Lidar group consists of project scientist Harvey Melfi, meteorologist/data analyst Rich Ferrare, and systems engineer/project manager Dave Whiteman. The Ozone Lidar group consists of project scientist, Tom McGee, laser physicists Jim Butler and John Burris, Rich Ferrare and Dave Whiteman.

All of the lidar equipment is housed in a mobile trailer allowing relocation of the experiment. Both experiments are nighttime operating only. The experimental equipment includes a 70 Hz Xe-Cl excimer laser (308 nm), 10 Hz Nd:YAG laser (355 nm), 30 inch Dahl-Kirkham telescope, custom designed optics package, photomultiplier tube detectors and photon counting signal measurement system. The system is controlled by a DEC LSI-11/73 computer providing experiment control and near real-time graphics output with a vector co-processor used for real-time data processing.

Water vapor measurements make use of a weak molecular scattering process known as Raman scattering. It is characterized by a shift in wavelength of the scattered beam of light relative to the incident one. Some of the energy of the incident photon is converted to vibrational/rotational energy within the molecule leaving the scattered photon shifted to a slightly longer wavelength. The amount of this wavelength shift depends on the vibrational/rotational energy level structure of the particular molecule being excited and is unique to it. For a photo of certain incident wavelength, therefore, the shifted wavelength of the scattered photon is a signature of the molecule. Melfi (1972) has shown that the ratio of the Raman backscattered signal from water vapor to that of nitrogen is proportional to the water vapor mixing ratio, figure 1., assuming that the atmospheric transmissivity at the two different wavelengths is the same.

When performing water vapor measurements, we are able to acquire profiles of water vapor mixing ratio from near the ground to beyond 7 km every 2 minutes. By forming a color composite image of the individual profiles, the spatial and temporal evolution of water vapor is visible with vertical resolution of 75 - 150 meters and temporal resolution of 2 minutes. During two intensive field missions in 1987, one at Greenbelt, Maryland the other at Falmouth, Massachusetts, we successfully measured the evolution of the water vapor structure during various meteorological significant events such as cold and warm frontal passages and atmospheric gravity waves. During both of these missions, we acquired at least a week of continuous nighttime data.

The ozone lidar is intended for use as a cross-calibration facility for other stationary ozone lidar systems. This new system is undergoing testing in anticipation of its first field deployment in July 1988, at Table Mountain, California to perform intercomparison measurements with a ozone lidar developed by JPL.

The ozone measurement employs the technique known as differential absorption. The backscattered laser radiation from two different wavelengths is measured. One of these wavelengths is strongly absorbed by ozone while the other is essentially unabsorbed. By comparing the two return signals on a height-by-height basis, one can determine the absorption due to ozone and thus derive the ozone number density, figure 2.

We have successfully measured 308 nm returns from 80 km with an averaging period of 6 hours. Using these data and a standard atmosphere density curve, we have derived an ozone number density profile which agrees very well with the standard ozone curve between 20 and 40 km. We will soon use the Nd:YAG 355 nm data to derive the actual density curve implementing the full differential absorption technique.

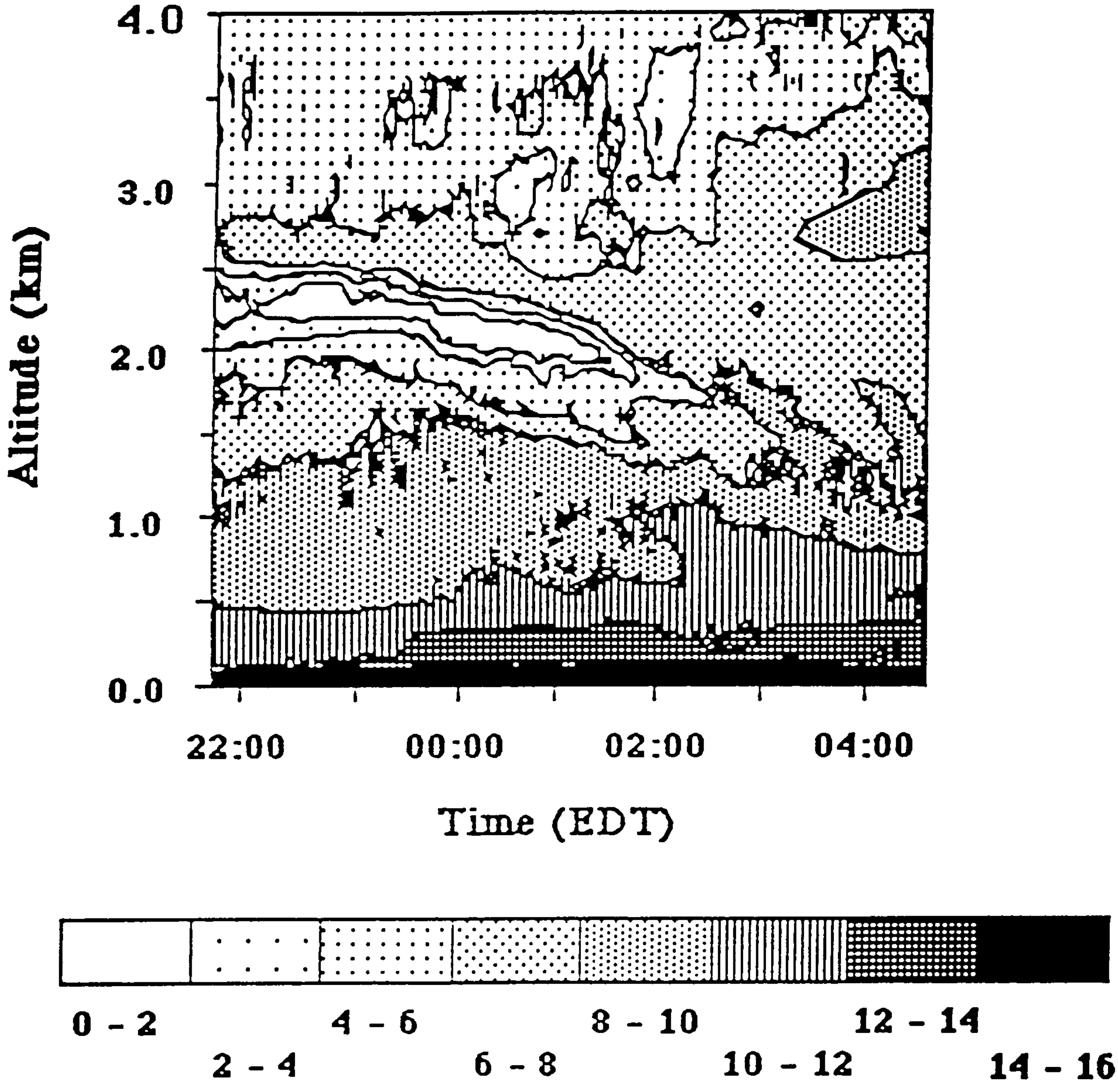

Figure 1. Water Vapor Mixing Ratio (g/kg)
June 6 - 7, 1988

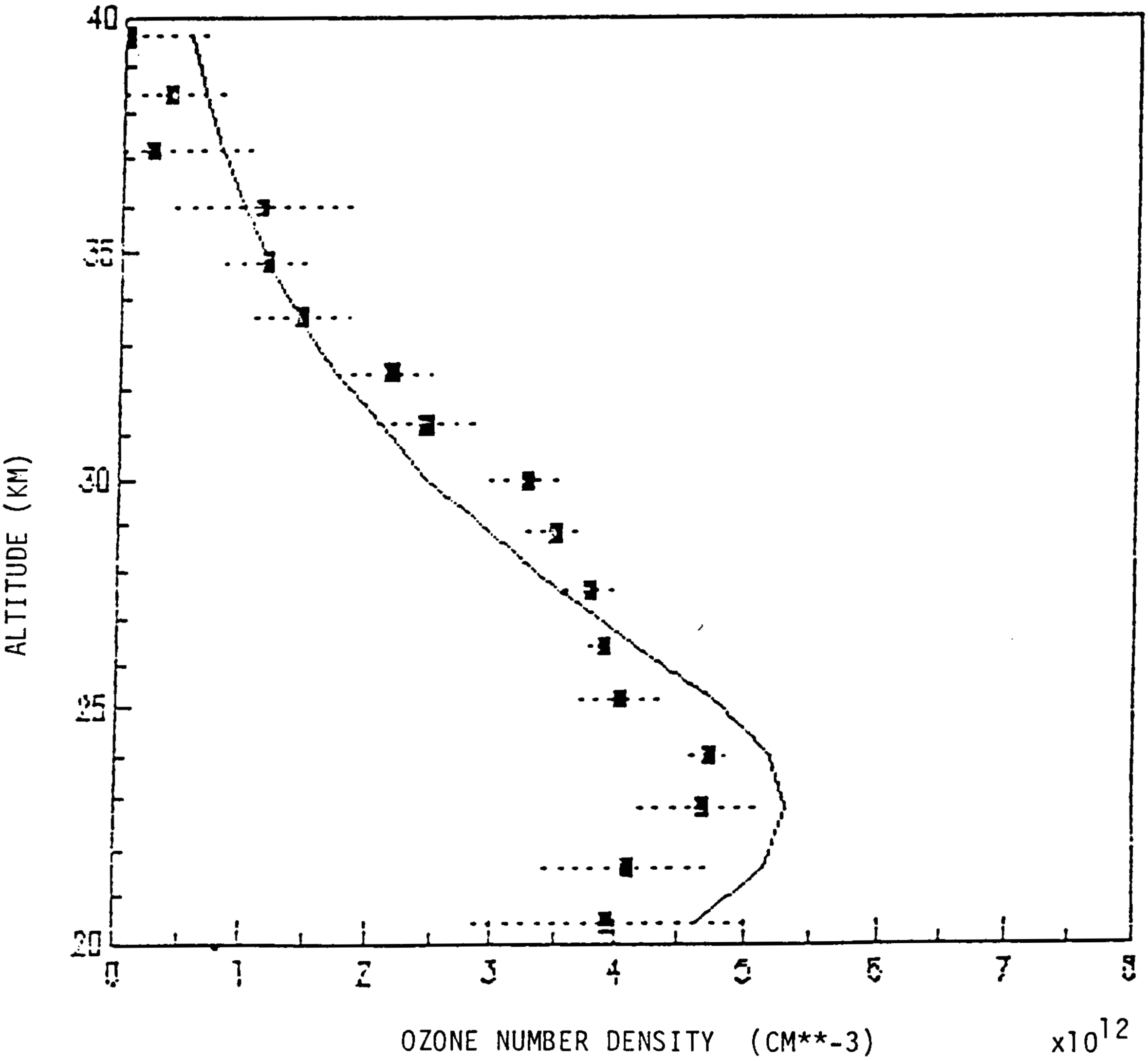

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Figure 2.