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LIDAR MEASUREMENTS OF STRATOSPHERIC OZONE, TEMPERATURE AND AEROSOLS AT THE MAUNA LOA AND TABLE MOUNTAIN NDSC STATIONS.

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INTRODUCTION

Two high power lidar systems are located at Table Mountain (TMF) in southern California (34.4° N, -117.7° W, elevation 2.3 km) and Mauna Loa (MLO), Hawaii (19.5° N, -111.6° W, elevation 3.4 km). These similar systems use the differential absorption lidar (DIAL) technique to measure ozone profiles from ~15 km to >50 km altitude and use Rayleigh scattering to measure temperature profiles from ~30 km to >70 km altitude. After the eruption of Mt. Pinatubo in June 1991, the TMF lidar was not able to make accurate measurements of ozone in the regions of high aerosol loading. The newer system at MLO can measure ozone, and also temperature, in regions of high aerosol by using the Raman augmentation to the DIAL technique [*McGee et al, 1993*]. The Rayleigh method for measuring temperature is only valid in regions where aerosol concentration is negligible. The TMF lidar has been in routine operation since February 1988 and the new system was installed at MLO in July 1993. Mauna Loa is a primary station site within the Network for the Detection of stratospheric Change (NDSC) and Table Mountain is both a complementary site and an intercomparison and test research site for many of the primary instruments.

TABLE MOUNTAIN, CALIFORNIA

The lidars, data analysis procedures, etc., at TMF have been fully described elsewhere [*McDermid et al, 1990a, 1991*]. The ozone DIAL system has also undergone extensive intercomparison and validation [*McDermid et al, 1990b,c,d*]. A summary and climatology of ozone derived from four years of lidar results (essentially pre-Pinatubo) has also been published elsewhere [*McDermid, 1993*]. The distribution of lidar measurements at TMF is summarized in table 1.

	1988 Ozone	1989 Ozone	1990 Ozone/T	1991 Ozone/T	1992 Ozone/T	1993 Ozone/T	TOTAL Ozone	TOTAL Temp.
JANUARY		13	2	7	9	2	33	20
FEBRUARY	7	10	4	5	8	4	38	21
MARCH	3	9	2	5	9	11	39	27
APRIL	4	11	4	8	13	13	53	38
MAY	12	11	1	7	13	12	56	33
JUNE	8	18	6	16	14	16	78	52
JULY	5	23	13	11	7	13	72	44
AUGUST	8	17	13	3	12	6	59	34
SEPTEMBER	1	15	9	12	8	9	54	38
OCTOBER	19	12	16	15	7	10	79	48
NOVEMBER	13	16	7	10	10	6	62	33
DECEMBER	13	2	6	3	4	3	31	16
TOTAL	93	157	83	102	114	105	654	404

Table 1. Summary of lidar measurements at TMF

The evolution of the aerosols from the eruption of Mt. Pinatubo has been followed using lidar measurements of the backscatter at three wavelengths, 353 nm, 532 nm and 1064 nm. As an example, the maximum backscatter ratio at 353 nm is plotted as a function of time since the eruption in figure 1.

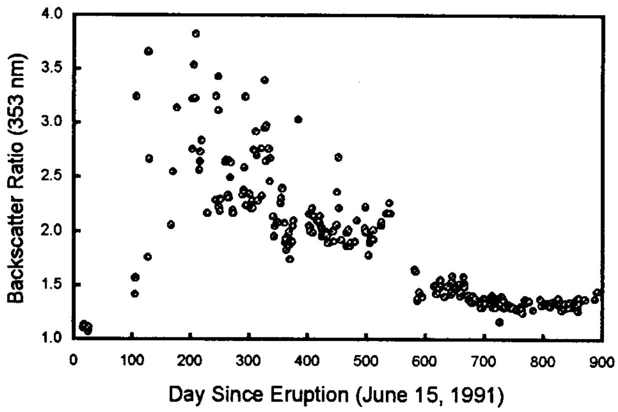

Figure 1. Maximum backscatter ratio at 353 nm as a function of time since the eruption of Mt. Pinatubo.

Since the launch of the Upper Atmosphere Research Satellite (UARS) in September 1991 the TMF lidar has played an important role in the correlative measurements and validation program for instruments on the satellite. Both Table Mountain and Mauna Loa are within the latitude boundaries for UARS measurements when the spacecraft is looking either north or south. There is therefore a continuous record for intercomparison and several hundred profiles of both ozone and temperature have been compared. While there are some problems caused by the different primary units of measurement, i.e., the lidar measures number density versus absolute altitude and UARS measures mixing ratio versus pressure altitude, the ozone profiles generally agree to within 10%. The temperature profiles also agree well and the UARS and lidar results appear to show slightly greater seasonal variations than are indicated by the NMC data. These intercomparisons and other recent developments will be summarized in the presentation.

MAUNA LOA, HAWAII

A new lidar system was installed at the NOAA Mauna Loa Observatory in July 1993. This system incorporates a number of improvements over the TMF lidar including the addition of Raman receiver channels at 332 nm and 385 nm and an optical chopper to reduce the signal-induced-noise.

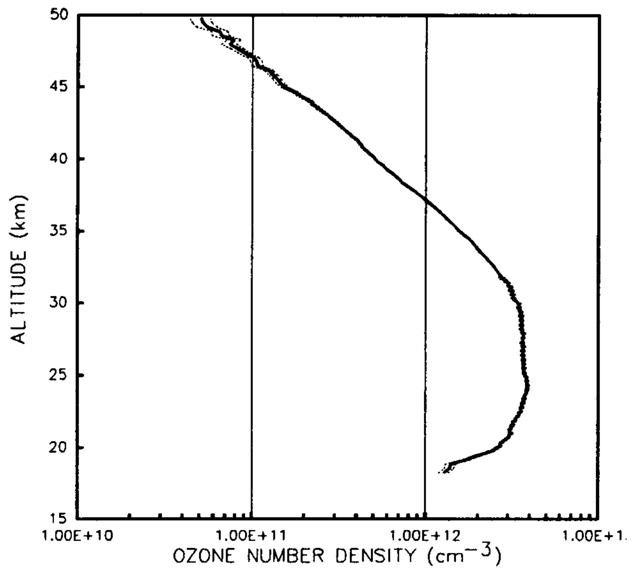

Figure 2. MLO ozone profile, 1/27/94.

The Raman channels are used to obtain ozone and temperature profiles in the regions of aerosol layers. The aerosol backscatter ratio profile is also obtained from comparison of the lidar returns at 353 nm and 385 nm, thus eliminating the need for a reference atmospheric density profile.

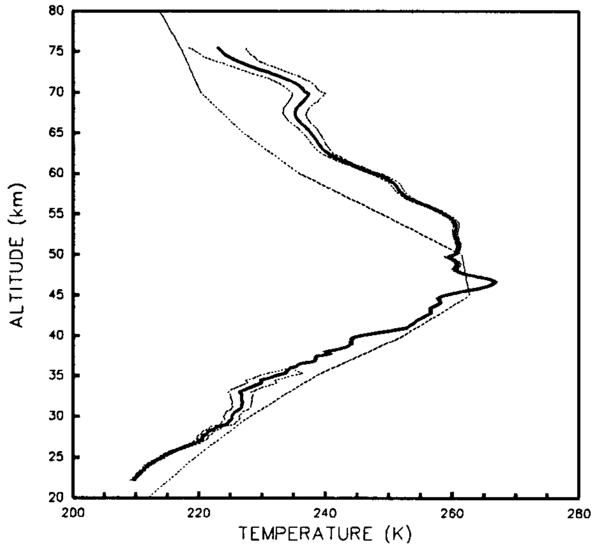

Figure 3. MLO temperature profile, 1/27/94. Dashed line is CIRA reference atmosphere model.

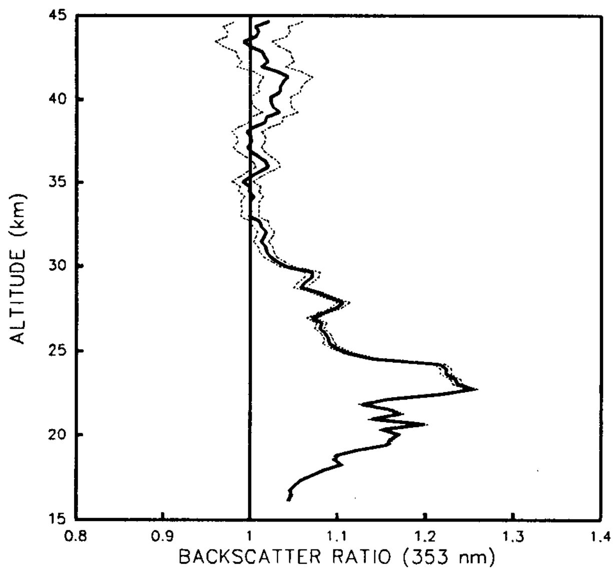

Figure 4. MLO aerosol profile, 1/27/94

Figures 2 through 4 show typical examples of ozone, temperature and aerosol profiles, in this case measured on January 27, 1994. The dotted lines about each profile represent the error bars from the photon counting. It can be seen that the measurements derived from the Raman channels have higher errors because of the reduced signal levels. However, ozone and temperature measurements in regions where aerosols are present can now be obtained reliably. This is important since it appears that there is still considerable aerosol loading in the tropics. Aerosol layers above 30 km altitude are still occasionally seen.

The lidar temperature profile can be used to convert the ozone concentration to mixing ratio. Pressure altitudes are also obtained from the temperature analysis. Figure 5 shows an example, again for January 27, 1994, of the calculated mixing ratio profile. Since the lidar temperature profile does not go as low as the ozone profile, a model temperature must be used at the bottom of the profile. In figure 5 it can be seen that the mixing ratio profile derived using the lidar temperature and that using the model temperature agree perfectly. Also shown on figure 5 are some ozone values from the Microwave Limb Sounder (MLS) onboard UARS. The results from the two closest overpasses are shown. Again, the agreement is very good.

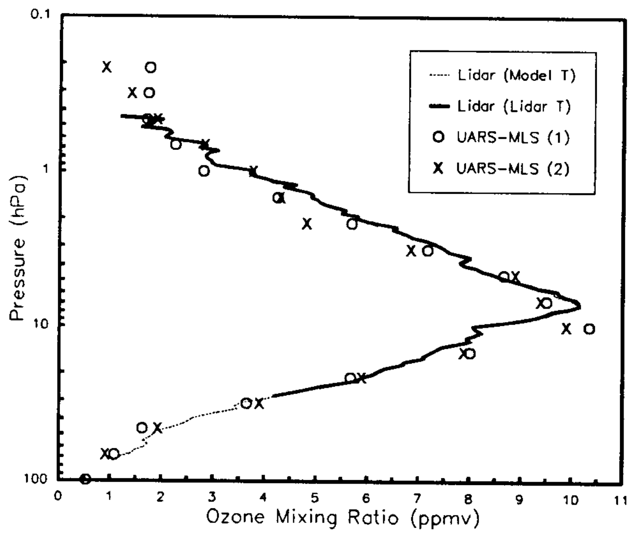

Figure 5. Lidar MLO ozone profile converted to mixing ratio and comparison with two closest UARS overpasses.

Ongoing developments, results, and intercomparisons will be discussed.

Acknowledgments

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