A-1.6 Studies on Variation of the ozone Layer using Observed Data

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Abstract Data obtained with an ozone lidar at the National Institute for Environmental Studies (NIES) were estimated and analyzed. Methods to check the systematic errors were carefully examined. Comparison with the data observed with the satellite sensor SAGE II was carried out to confirm the accuracy and good agreements were obtained. Thus, vertical profiles of ozone from 15 km to 45 km have been archived. Temperature profiles from 30 km to 80 km can be also obtained from the off-resonant signal of the ozone lidar which could give information on dynamical; motions in middle atmosphere and effects of ozone depletion and global warming. Seasonal variations of ozone were different with altitude. A method to correct the effects of the Pinatubo aerosols on the ozone lidar measurements were discussed.

Key Words Ozone Lidar, Vertical Profiles of Ozone, Variations of Ozone, Pinatubo Aerosols, Network for the Detection of Stratospheric Change (NDSC)

Lidars are expected to measure vertical profiles of ozone, aerosols and temperature with high accuracy and good height resolution and to give data for trend analysis. In March 1988, NIES installed an ozone lidar (DIAL) system to measure the ozone profiles from the troposphere to the upper stratosphere (~45 km). Observation has been carried out since August 1988 and archived data whose qualities are checked. In this report, the outline of the NIES ozone lidar, obtained data and variations of ozone are described.

The NIES ozone lidar system consists of two subsystems; a high altitude system (HA system) and a low altitude system (LA system). Fig. 1 is a block diagram of it (Sugimoto et al., 1989). A XeCl excimer laser is used as the light source for the on-resonant wavelength (308 nm) and another excimer laser, XeF laser, emits the light with the off-resonant wavelength (351 nm). A Raman shifter with deuterium generates another off-resonant 339 nm laser beam from the 308 nm laser beam. The directions of the beams transmitted are the same for 308 nm and 339 nm. The direction of this beam and that for 351 nm can be independently adjusted. Therefore, the alignment of the laser beams can be checked by comparing the 339 nm signal and 351 nm signal in the case that effects of aerosols are negligible. The backscattered light is collected by the 2 m telescope and is sent to the receiving optics and detectors.

The main sources of the systematic errors are misalignment of transmitting or receiving optics, dead time of photon counters (saturation of photon counters) and aerosol effects (Sasano et al., 1989). Ratios between 339 nm and 351 nm signals can be used to check the alignment of the laser beams transmitted because they are independently adjusted. Aerosol effects can be also detected using this ratio in the case that the deviation of this ratio from the constant value has correlation with the aerosol profile. Comparison between the ozone profiles derived from a pair of signals for 308 nm and 339 nm, and 308 nm and 351 nm gives similar check. Figure 2 depicts an example of these comparisons. The agreement is very good and it is difficult to distinguish the two profiles. This means the first that the effects of the stratospheric aerosols on the ozone lidar measurements are negligible within the statistical errors. This means the second that the alignment of the laser beam transmitted are probably good as mentioned above.

Another comparison was carried out with data provided by the satellite sensor SAGE II. Results showed good agreement for the individual and the zonal-mean profiles (Fig. 3). Estimated differences between ozone profiles measured with the ozone lidar and with the SAGE II was about 10 % over the stratosphere (Nakane et al., 1993).

Lidar observation of ozone profiles with the NIES Ozone Lidar started in August 1988. Temporal variations of ozone at 20, 25, 30, 35 and 40 km since then are depicted in the Fig. 4. Seasonal variations are different with altitude. Ozone density is high in winter and low in summer at 20 km; high in summer and low in winter at 30 and 35 km. This difference of the seasonal variation with altitude is consistent with the mechanism of the seasonal variations in the lower and upper stratosphere generally understood: Transport effects are of dominant in the lower stratosphere and photochemical effects in the upper stratosphere. Figure 5 shows the temperature profiles observed during DYANA campaign measured using the off-resonant signals of the ozone lidar (Nakane et al., 1992). Temperature in the upper stratosphere and mesosphere is expected to decrease both with the ozone depletion and global warming, but with different manner. Thus, the off-resonant signals of ozone lidars give information on the middle atmospheric dynamics and the effects of ozone depletion / global warming.

After the arrival of the "Pinatubo aerosols", data below 30 km were contaminated by the systematic errors due to the aerosols. However, those errors could be corrected when we give appropriate parameters for aerosol optical parameters. The multiple wavelength configuration of our ozone lidar permits to check the correction. Fig. 6 demonstrates the effect of the aerosol correction.

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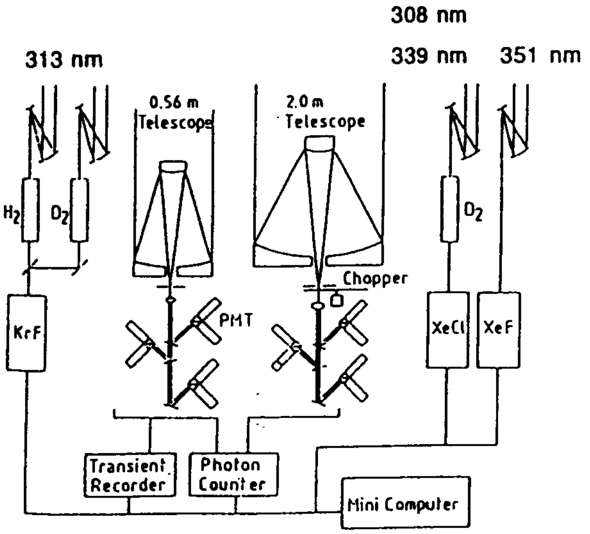

Fig. 1 Block diagram of the ozone lidar.

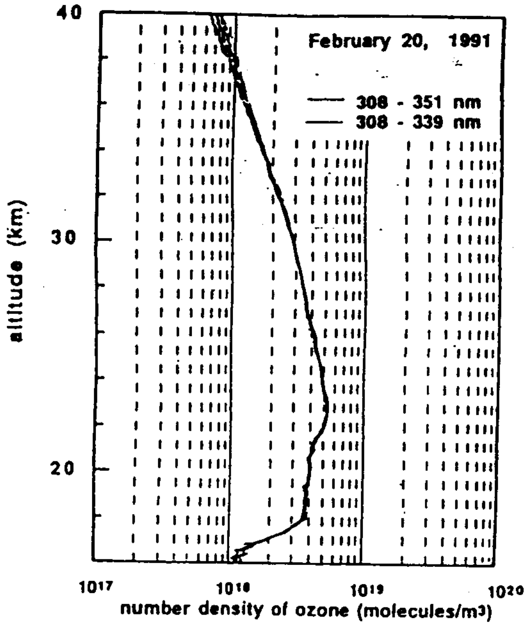

Fig. 2 Ozone profiles with statistical errors derived from the combinations of signals for 308 nm and 339 nm (thin curves), and 308 nm and 351 nm (bold curves)(Nakane, et al.,1992a).

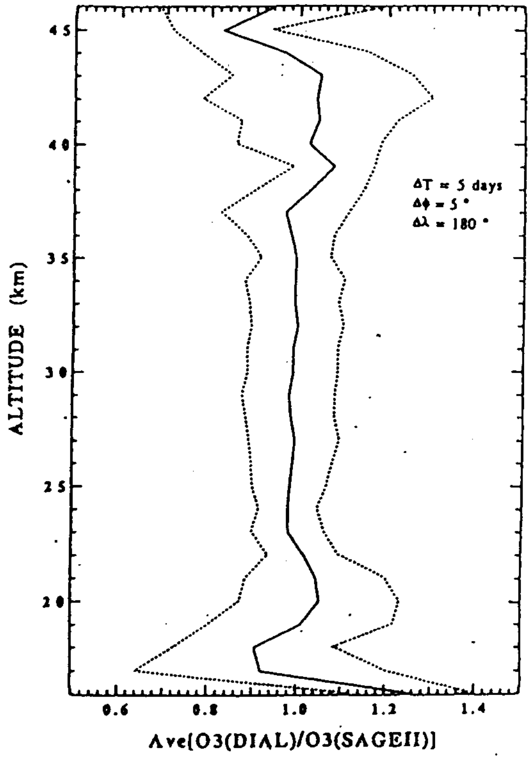

Fig. 3 Ozone lidar and SAGE II comparison. The average of the ratios and its variability for zonal-mean profile comparisons (Nakane et al., 1993).

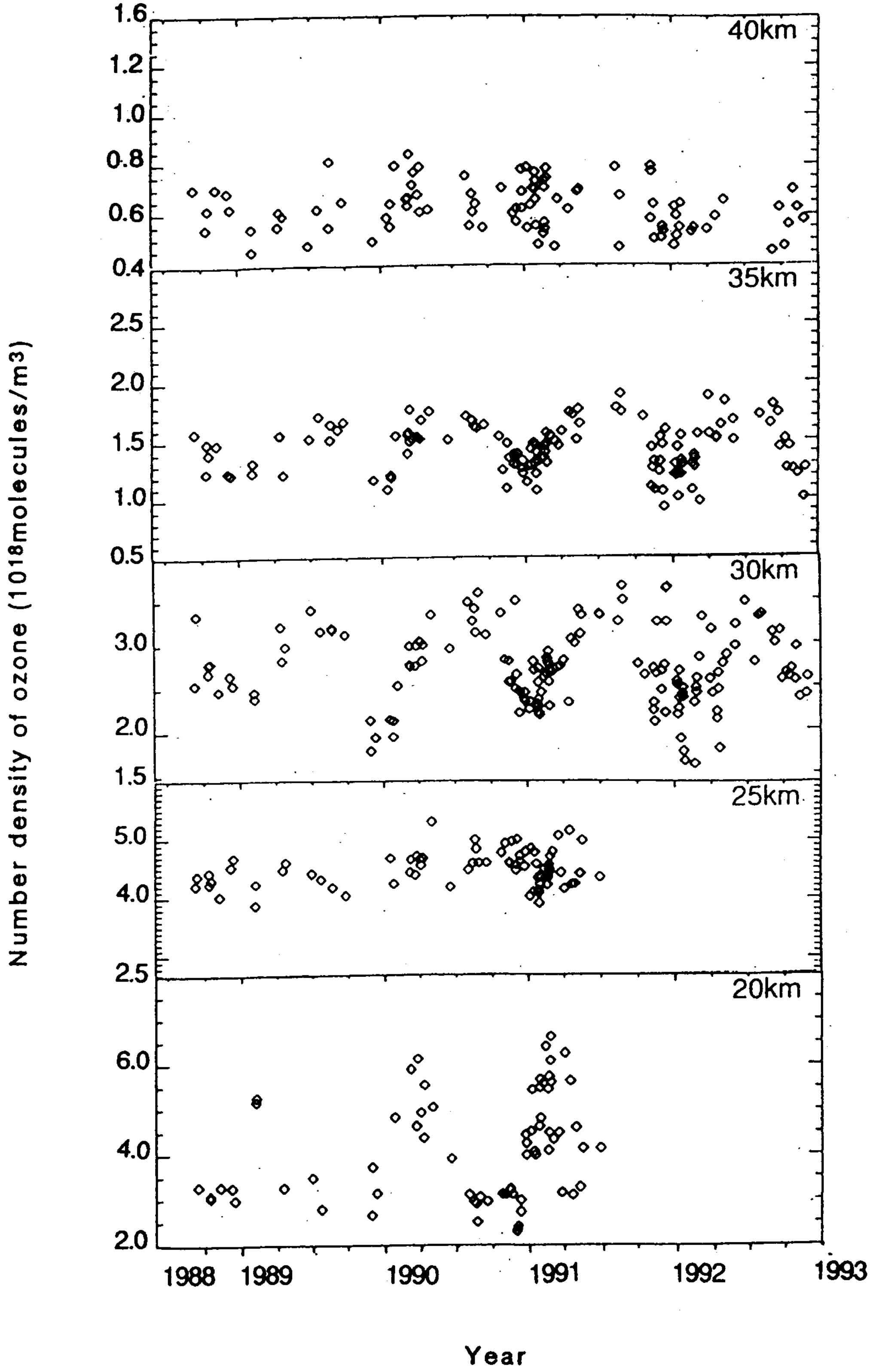

Fig. 4 Variations of ozone at 20, 25, 30, 35 and 40 km in altitude.

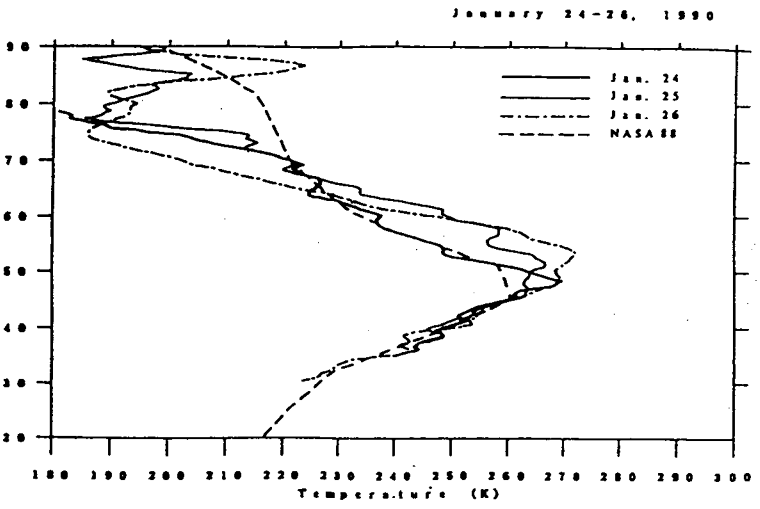

Fig. 5 Change of the temperature profiles during DYANA (Nakane, et al.,1992b).

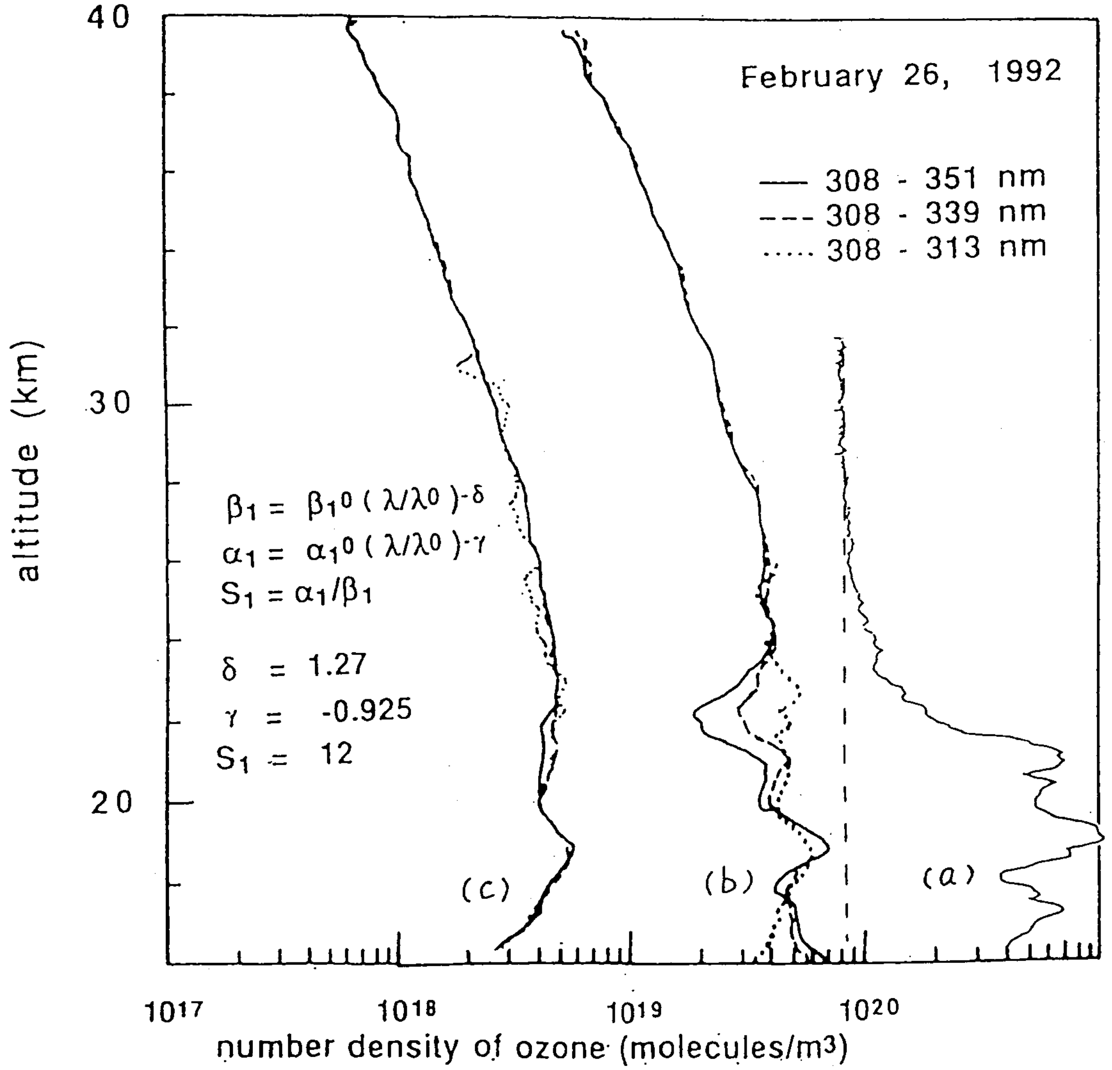

Fig. 6 Effects of aerosol corrections on the ozone lidar data obtained after the Pinatubo eruption.