A-1.5 Effects of Volcanic Eruptions on Ozone Layer

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Abstract The stratospheric aerosols due to the eruption of Mt. Pinatubo were observed at Tsukuba, Wakkanai and Poker Flat in Alaska. A part of the aerosol layer arrived at Tsukuba two weeks after the eruption, which is much faster than expected. The transport processes, variations and size distributions of the stratospheric aerosols were discussed.

Key Words Pinatubo Volcanic Eruption, Stratospheric Aerosols, Laser Radar, Ozone Layer, Meridional Transportation

1. Introduction

The major volcanic eruptions of Mt. Pinatubo on June 12 and 15, 1991 injected large amount of sulfuric dioxide into stratosphere, which were converted to sulfate aerosols. These aerosols should have affected the ozone layer and the global total ozone did decrease extraordinarily during two years from 1992 to 1993. However, it is still now difficult to discriminate the direct and indirect effects of the Pinatubo aerosols. Therefore, precise information on the Pinatubo aerosols is important.

2. Objective

The goal of this study is to obtain the data on the Pinatubo aerosols necessary to estimate the effects on the ozone layer.

3. Research Method

Vertical distributions of the Pinatubo aerosols have been observed with lidars at Tsukuba (36°N, 140°E; Natl. Inst. Environ. Studies), at Wakkanai (45°N, 141°E; Communications Research Lab.), at Poker Flat in Alaska (64.5°N, 147.5°W; STEL, Nagoya University). The measurements to estimate the size distributions of the aerosols were carried out using aureolemeter at Tsukuba and a two wavelength lidar at Wakkanai. Meteorological data supplied by Japan Meteorological Agency (JMA) were used for the analysis of the data obtained.

4. Results

4.1 Transport of the Pinatubo aerosols

The Pinatubo aerosols were first observed at Tsukuba on June 28, 1991, only two weeks after the eruption (Fig. 1). Backward trajectories at 16, 18, 20, 22 and 24 km calculated using the JMA global analysis show that there were fast westerlies present at 16 km and easterlies higher than 20 km. The volcanic aerosols observed on June 28 seem to have moved westward first, then northward and later eastward by an anticyclone, according to the JMA weather map. It is interesting

that the meridional transports in the lower stratosphere occur not only homogeneously but also sporadically induced by cyclonic or anticyclonic systems. Thin aerosol layers were sporadically observed higher than 20 km in July and August. In September and October, dense aerosol layers were observed in the westerly wind altitude region, which seems to correspond to the arrival of the main body of the Pinatubo aerosols (Fig.2).

At Wakkanai, the lidar measurement started on August 28 and a small peak was seen at 18 km then (Fig. 3). Dense aerosol layers were observed in October and the largest scattering ratio was observed on November 22. Variations of the stratospheric aerosols were large in 1991 and became smaller in 1992.

At Poker Flat in Alaska, lidar measurements of the stratospheric aerosols were made during the periods from December 1991 to March 1992 and from January 1993 to March 1993. Aerosol layer had arrived at Poker Flat on mid December (Fig. 4). As the tropopause height was about 11 km then, the layer 3 around 26 km corresponds to the layer higher than 30 km in the middle latitude and the layer around 17 km corresponds to the layer observed everywhere. Backward trajectories show that the airmass at 27 km was transported rapidly from southern area while the airmass at 17 km was circulating along the polar vortex.

4.2 The Size Distributions of the Stratospheric Aerosols

The size distribution of the stratospheric aerosols is very important because radiation transfer process depends on it and the surface area density of the stratospheric aerosols is determined by it. The rates of the heterogeneous processes on the stratospheric aerosols related to the ozone depletion are thought to be proportional to the surface area density of the aerosols. At Tsukuba, measurements of the size distribution are carried out using the aureolemeter and the lidar. Details are described in A-3.3 in this report. At Wakkanai, the two wavelength lidar measurements are carried out to obtain information on the size distribution of the aerosols. Fig. 5 depicts the ratio of the aerosol mixing ratio (= scattering ratio -1) at two wavelengths. The ratio was almost constant with altitude on October 26, 1992 indicating the homogeneity of the aerosol size distribution with altitude.

4.3 Decay of the Stratospheric Aerosol Layer in Alaska

Comparing the vertical profiles of the stratospheric aerosols measured in 1992 and 1993, the decay rate of the aerosol layer was smaller than expected.

5.Conclusion

The effects of the eruption of the Mt Pinatubo on the stratospheric aerosol layer was approximately understood. The meridional transport of the aerosols were found to be not simple and rapid transport processes were assigned. The aerosol size distribution and information on the vertical profile of it were obtained, which are important for estimation of the effects of the aerosol layer on the ozone layer.

References

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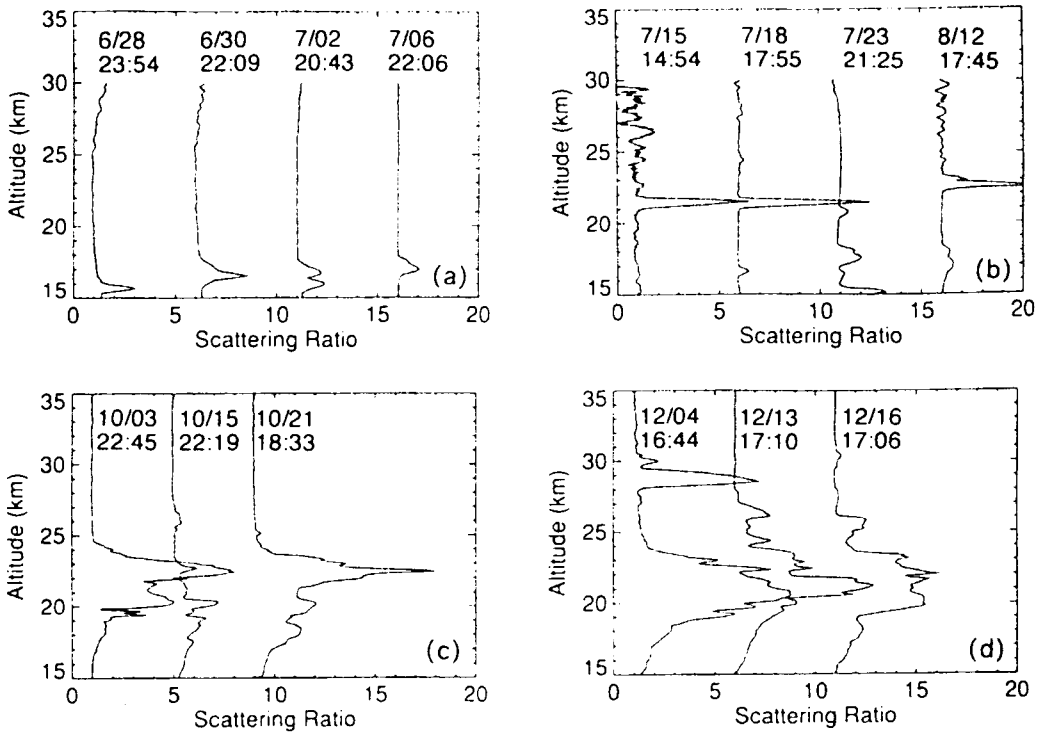

Fig. 1 Scattering ratio profiles over Tsukuba observed by the NIES lidar in 1991 (Hayashida and Sasano, 1993).

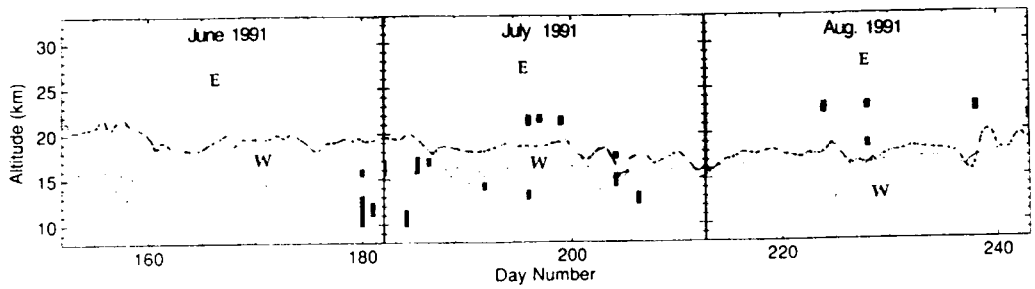

Fig. 2 Time -height cross section of westerly-easterly component of the wind over Tsukuba (Hayashida and Sasano, 1993).

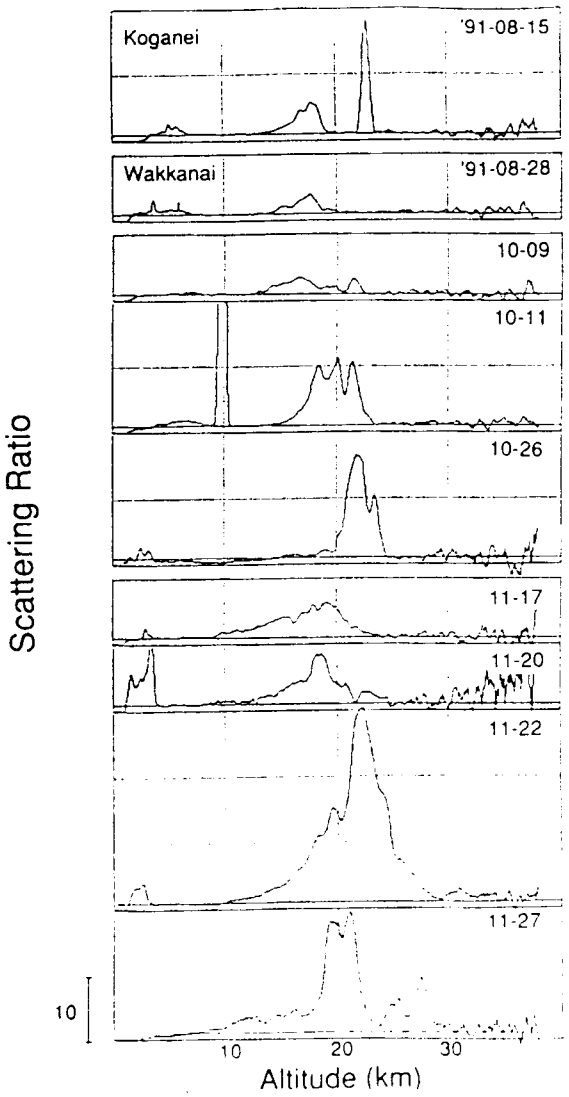

Fig. 3 Aerosol Vertical profiles observed at Wakkanai (Itabe et al.,1993)

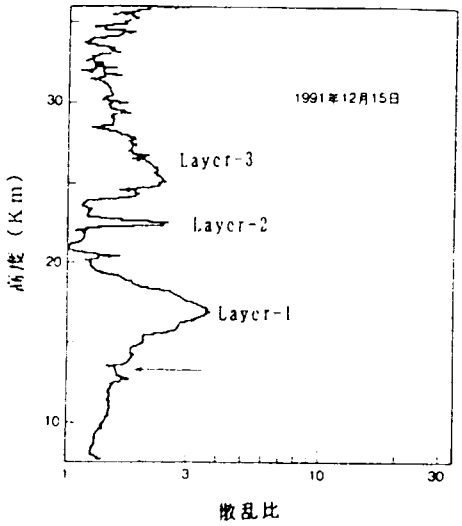

Fig.4 The aerosol profiles at Poker Flat in Alaska (Iwasaka, 1993).

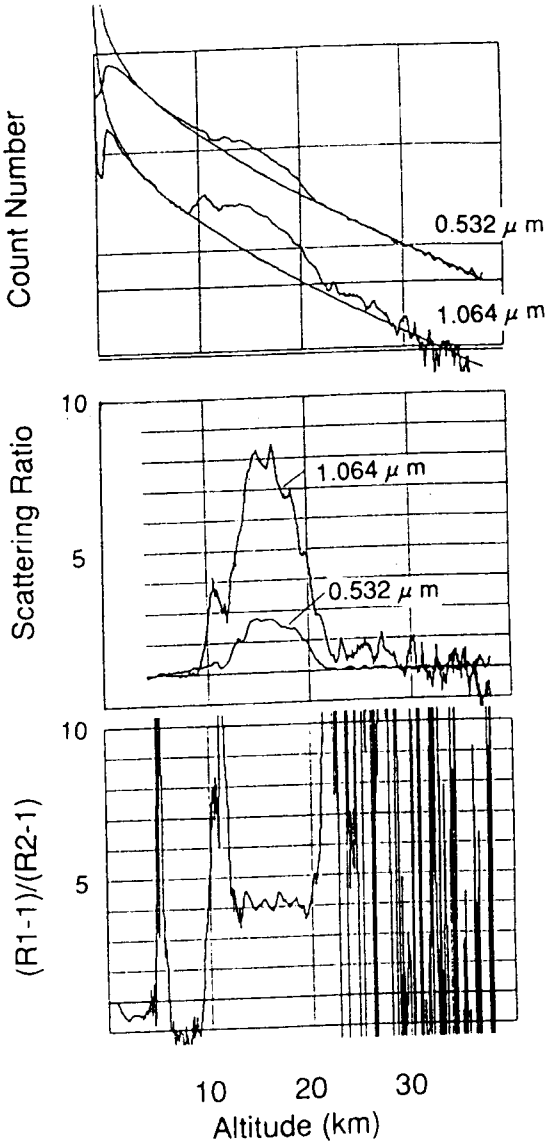

Fig. 5 Results of the two wavelength lidar measurement at Wakkanai (Itabe et al.,1993).