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LIDAR MEASUREMENTS OF STRATOSPHERIC AEROSOL OVER TOYOKAWA, JAPAN, AFTER THE ERUPTION OF THE JUNE 1991 MT.PINATUBO

-- Stratospheric temperature anomalies due to the Pinatubo aerosol --

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INTRODUCTION

Mt.Pinatubo(15°N, 120°E) had explosively erupted in June 1991, and injected large amount of SO2 gas into the stratosphere, which is estimated to be 20 megatons, three times of that of El Chichon event in 1982. Stratospheric aerosols have unprecendently enhanced through the gas-to-particle conversion processes from the injected SO2 gas. We have been observed the stratospheric aerosol layer by a lidar at Toyokawa, Japan. One of the purposes of this paper is to discuss the variation of stratospheric aerosol layer observed by our lidar.

Stratospheric aerosol layer has significant effects on atmospheric chemistry or radiation budget. For instance, ozone destruction can occur through heterogeneous processes as reported by previous papers. Aerosols scatter and absorb solar or surface radiation, and disturb stratospheric condition. Many investigators have suggested that stratospheric temperature has increased by aerosols which has been disturbed by large volcanic eruptions. The other purpose of this paper is to study effects of stratospheric aerosols on temperature. No study has ever been made on comparison of vertical structures of temperature and aerosols.

LIDAR OBSERVATION

Our lidar is located at Toyokawa(35°N,137°E), Japan, and has observed stratospheric aerosols since May 1991. The laser is a Nd:YAG laser oscillator with wavelength of 532 nm at the frequency of 10 Hz, maximum output power is 1.0 J. Receiving telescope is 50 cm in diameter. One photomultiplier is used to detect intensity and polarization property of return signals. Vertical resolution of our lidar system is 300 m.

RESULTS

Fig. 1 shows a variation of scattering ratio measured at Toyokawa. The first appearance of the Pinatubo aerosol layer had occurred in the end of June or beginning of the July at an altitude of about 17 km, just above the local tropopause. Then the layer altitude had risen with lager peak ratio with large fluctuation, and reached its highest phase since day 100 to 300, the layer thickness getting more large. After the day 300, the layer altitude began to decrease with less peak ratio and more layer thickness. Recently, the the stratospheric aerosol layer peak lies at an altitude of about 17 km with a scattering ratio of 1.5.

We can discuss the variation of stratospheric aerosol load from Integrated backscattering coefficient(IBC) value. Fig. 2 corresponds to the variation of the stratospheric aerosol mass. Since the eruption, the IBC value increased with large fluctuation, which is probably due to the horizontal inhomogeneity. The IBC value shows a plateau from the day 150 to 300, then began to decrease. In September 1992, IBC value had begun to increase again. This second enhancement of aerosols seems strange.because of its magnitude. There are probably two cause of the second enhancement. One is seasonal transportation of the stratospheric aerosol from tropical to polar regions, but this cannot seem to explain the magnitude of the second enhancement.. The other is a new volcanic eruption. Our lidar measurements shows there had been an aerosol layer with a high depolarization ratio in September 1992, suggesting lots of fresh volcanic materials. So we can conclude that a unknown volcanic eruption caused the second enhancement and elongates the life of the stratospheric aerosols. In March 1994, the stratospheric aerosol mass is far from the background condition.

TEMPERATURE AND AEROSOL LAYER

It is well known that stratospheric aerosol affect the temperature, but no study on the correlation of aerosol layer and temperature anomalies has ever been made. So we compare the vertical distribution of the aerosol and temperature anomalies. Temperature data are extracted from daily rawin sonde observation at Tateno(36°N, 140°E) and 1961-1990 average, then the monthly averaged vertical distribution of the temperature anomalies were made with seven standard pressure levels. Monthly averaged stratospheric aerosol layer profiles were made from our lidar measurements. Fig. 3 shows correlations of the aerosol layer and the temperature anomalies. There were positive anomalies within the stratospheric aerosol layer, and negative anomalies above and below the layer. These results agree with ratiative-convective model. But since November 1992, the correlation seems worse. We now cannot point out what caused that discrepancy.

SUMMARY

Enhancement of the stratsopheric aerosols caused by the June 1991 eruption of Mt. Pinatubo has been observed by lidar at Toyokawa, Japan. The disturbance was maximum in winter of 1991/1992 and was very large compared with the El Chichon event in 1982. In fall of 1992, stratospheric aerosols had enhanced again and then decreased, but has not returned to the background level in March 1994. According to the comparison with lidar and rawin sonde data, from August 1991 to October 1992, strong correlations in the vertical structure between aerosol and temperature anomalies were revealed.

There are some problems we should study. First, during observation, the stratospheric aerosol vertical distribution often showed multi-layered structure, which affect atmospheric radiation budget in the different way of a single layer. We should study temperature anomalies caused by the stratospheric aerosol with a multi-layered structure. Second, temperature variation affects atmospheric chemistry including aerosol formation and loss processes. Such effects on atmospheric chemistry should be revealed. Third, temperature varies atmospheric dynamics. We should consider the air motion caused by warming or cooling due to aerosols.

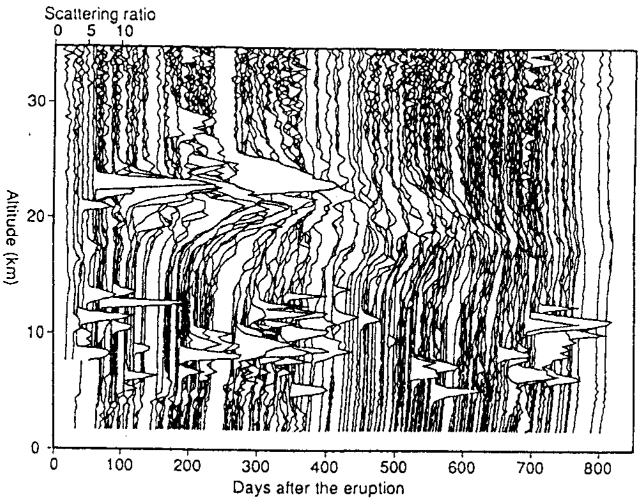

Fig.1 Scattering ratio measured at Toyokawa since the eruption of Mt.Pinatubo on 15, June.

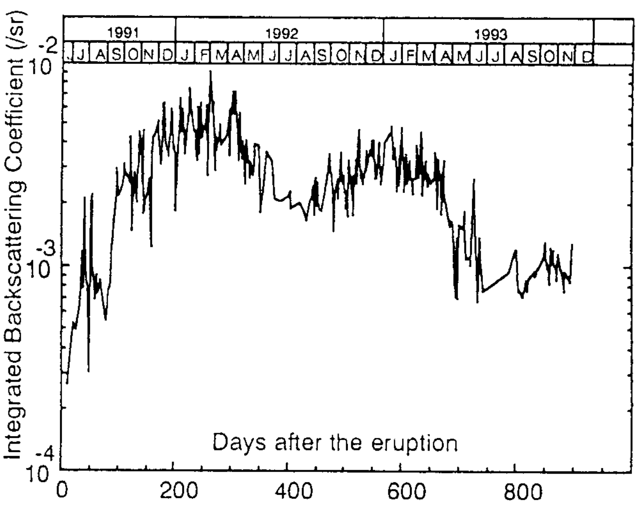

Fig.2 Variation of Integrated Backscattering Coefficient

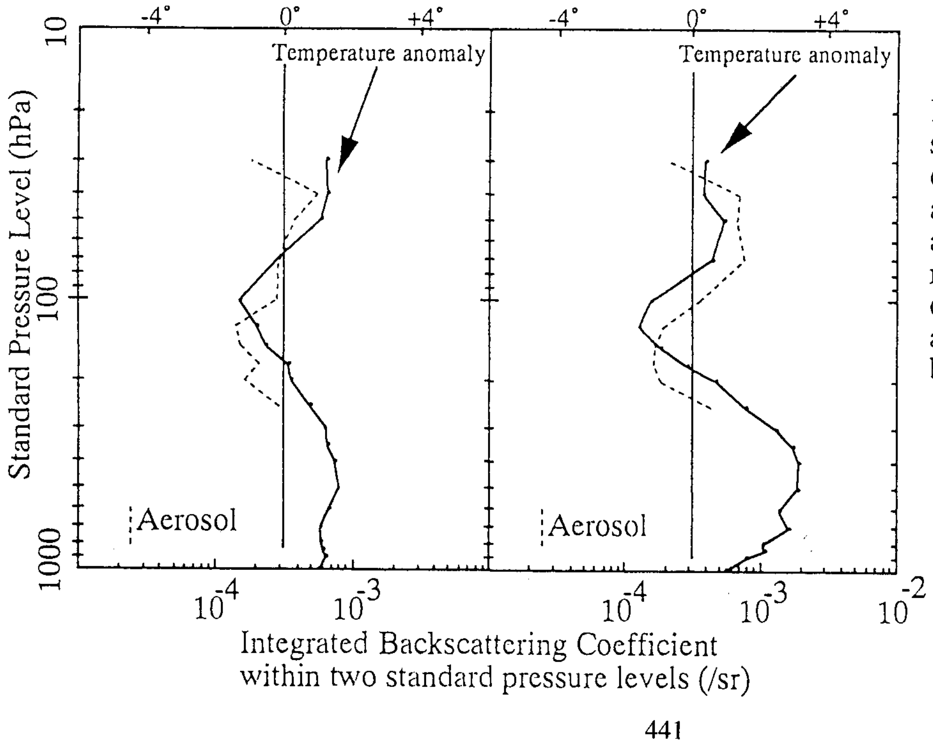

Fig.3 Examples of profiles showing a good correlation of vertical distributions of aerosol and temperature anomalies. One can easily recognize positive anomaly of temperature within the aerosol layer and negative below and above the layer.