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Global Lidar Monitoring of the Pinatubo Volcanic Aerosols and Their Effects on Climate

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1. INTRODUCTION

The Mt. Pinatubo (15.14°N, 120.35°E) on Luzon Island, Philippines, erupted violently on June 15, 1991 and large amount of volcanic ash, SO_2, and H_2O were injected into the stratosphere by the volcanic eruption[1]. The Total Ozone Mapping Spectrometer (TOMS) estimated approximately 20 megatons of SO_2 which is about three times that produced by the 1982 E1 Chichon eruption[2]. The ash reached as high as 29 km altitude with most of the cloud between 20 km and 25 km according to the SAGE II satellite measurements[3]. These large volcanic eruptions could influence the atmosphere and cause climatic effects on a global scale. In order to estimate the influence, we started a project entitled EPIC(Effects of the Pinatubo eruption on Climate) which is funded by the Science and Technology Agency(STA). The purposes of this project are to obtain the global data of the stratospheric aerosols injected by the eruption with lidars and other instruments, and to estimate the impact of the eruption on climate making use of these data and atmospheric model simulations.

2. GLOBAL LIDAR NETWORK FOR EPIC

Figure 1 shows the geographical locations of global lidar network for measurements of Pinatubo dust particles. Observations of the stratospheric aerosols have been made routinely at Stations of Tsukuba, Nagoya and Fukuoka, so their observations start from the initial stage of the Pinatubo volcanic event, the other stations were established for these cooperative observations. Observations started on August 28, 1991 at Wakkanai[4], September 19, 1991 at Okinawa[5], and November 19, 1992 at Lauder, New Zealand.

EPIC (Effects of the PInatubo eruption on Climate)

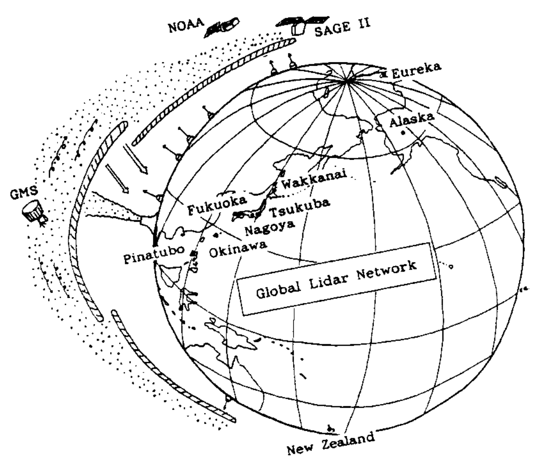

Fig.1 Geographical locations of the global lidar network for measurements of Pinatubo dust particles.

A new observatory was built at Eureka by Atmospheric Environment Service, Canada and there a Nd;YAG lidar was brought for measurements of stratospheric aerosols, polar stratospheric clouds and arctic haze by MRI and CRL in Japan in cooperation with Canadian group. Lidar observations at Eureka started in February 1993.

3. LIDAR OBSERVATIONAL RESULTS

Figure 2 displays on gray-scale time-height representation of scattering ratio at a wavelength of 532 nm over Tsukuba(36°N) after the eruption. An increase of aerosols originating from the Pinatubo eruption was observed first on June 28, 1991, at approximately 16 km. The layer was observed continuously since then. The upper layer, above 20 km, was observed first on July 15, there after it disappeared at all stations in Japan, but reappeared on August 6[6]. The maximum of scattering ratio was 14.8

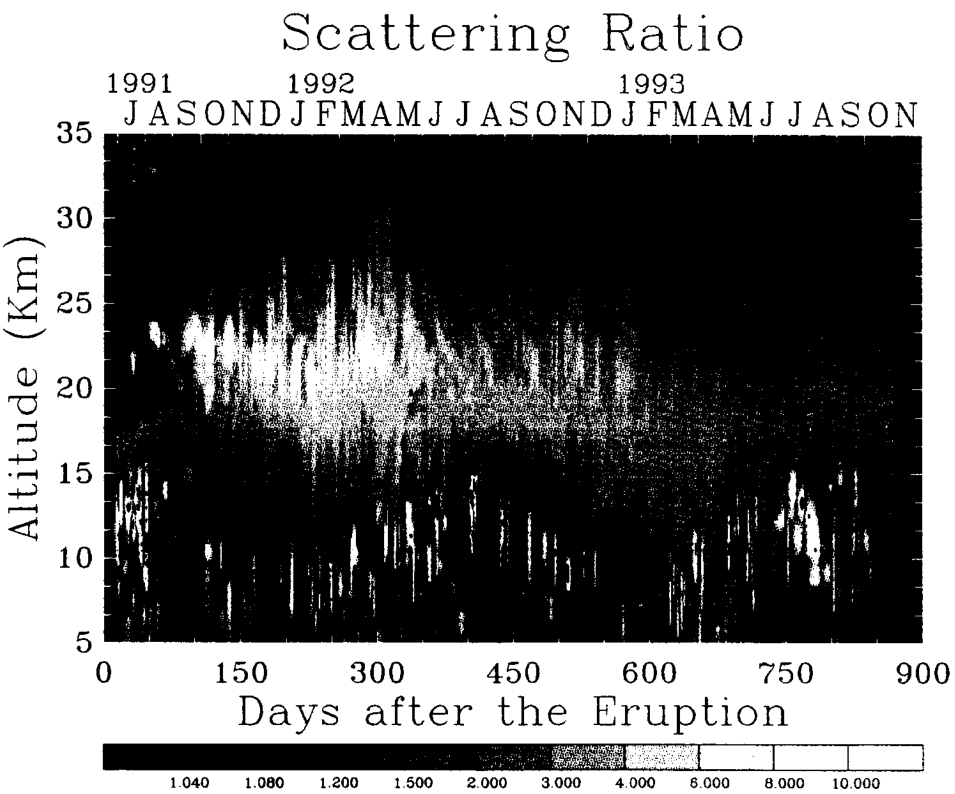

Fig.2 Gray-scale time-height representation of the scattering ratio at Tsukuba(36°N). Light parts wiht high scattering ratios below 15 km altitude show cirrus clouds.

on November 29 over Tsukuba and that was 22.5 on December 4, 1991 over Naha(26°N).

Thick aerosol layers existed around 22 km altitude from mid September 1991 to April 1992 over Tsukuba. It is evident that the stratospheric aerosols intruded into lower altitude below 15 km in winter and spring over Tsukuba.

Figure 3 represents scattering ratio profiles at 532 nm measured at Lauder, New Zealand, Okinawa and Tsukuba, Japan, Garmisch-Partenkirchen, Germany and Eureka Station, Canada on February 10 and 11, 1993. The maximum of scattering ratio was about 3 all over the lidar stations and the Pinatubo aerosol particles dispersed globally.

Figure 4 depicts the Integrated Backscattering Coefficient(IBC) at each 5 km height interval over Tsukuba after the Pinatubo eruption. The IBC at 20-25 km increased sharply from mid September 1991 and had almost the same magnitude until April 1992 although it varied from time to time. The IBC at 15-20 km increased almost linearly from mid September 1991 until February 1992. The IBC at 10-15 km increased from late autumn until early summer, and the IBC in the second season was larger than that in the first season since the Pinatubo aerosol layer have subsided by gravitation.

Figure 5 shows time variations of the total IBC over Tsukuba(36°N),

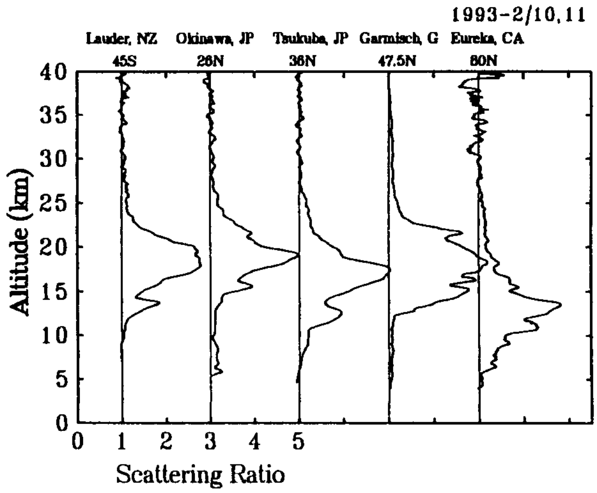

Fig.3 Scattering ratio profiles in February 1993. Note that peak scattering ratios are almost the same all over the stations.

Naha(26°N), Okinawa and Lauder(45°S). The maximum values of IBC were 5.1×10^{-3} sr^{-1} over Naha on February 25 and 7.1×10^{-3} sr^{-1} over Tsukuba on February 22, 1992 respectively. The IBC decreased comparatively monotonously over Naha while that over Tsukuba showed a seasonal variation with a winter maximum. The IBC over Lauder was larger than those over Tsukuba and Naha since mid April 1993.

4. EFFECTS OF THE PINATUBO ERUPTION ON CLIMATE

The stratospheric aerosol cloud increased dramatically after the Pinatubo eruption and had a major impact on climate. SO_2 injected by the eruption decayed with a 33 day e-folding time[7]. The ash particles persisted until January 1992 from the measurement of the depolarization ratio at 532 nm over Okinawa(26°S). Lower stratospheric temperature anomalies increased evidently after the eruption and returned to normal in spring 1993[8]. Tropospheric temperature anomalies decreased after the eruption in spite of the warm episode of ENSO in 1991/1992. The anomalies have remained negative at October 1993 as shown in Fig.6(K. Takano, private communication). And the influence of volcanic eruptions can be expected to produce changes in the northern hemisphere winter troposphere through stratospheric processes[9].

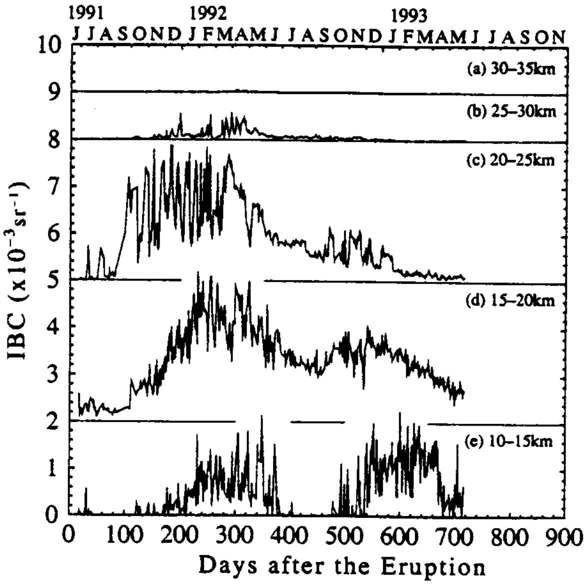

Fig.4 Integrated backscattering coefficient at 532 nm obtained at each 5 km height interval over Tsukuba.

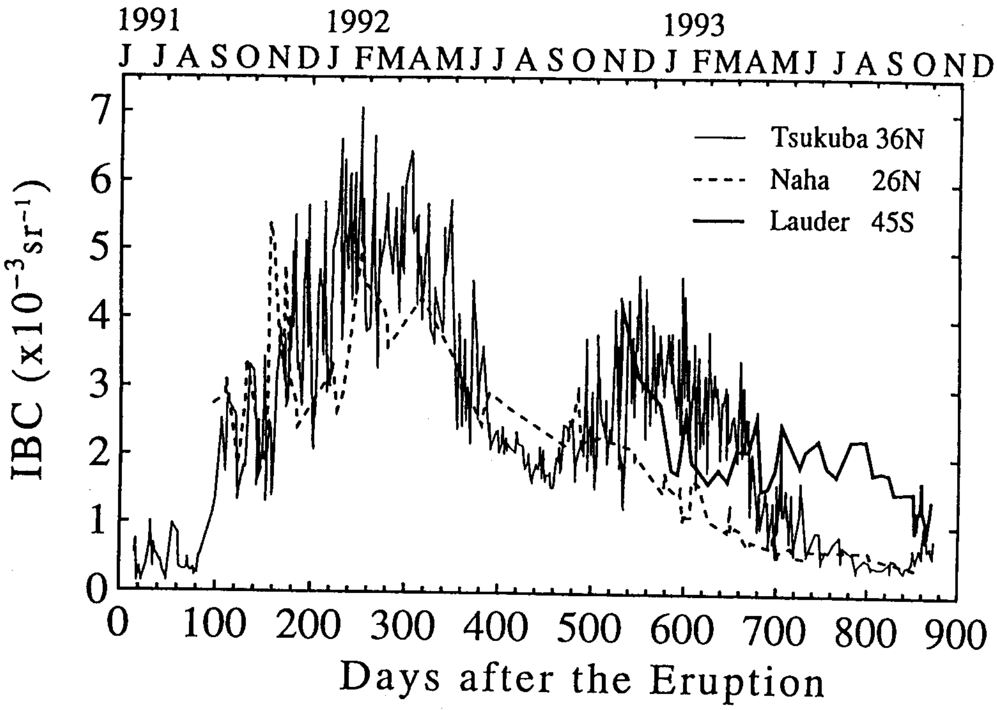

Fig.5 Total integrated backscattering coefficient above tropopause at three lidar stations.

The Mt. Pinatubo eruption had also a major impact on stratospheric species such as NO_2[10], HNO_3 and ozone[11] through heterogeneous chemical reactions due to the increased aerosol surface.

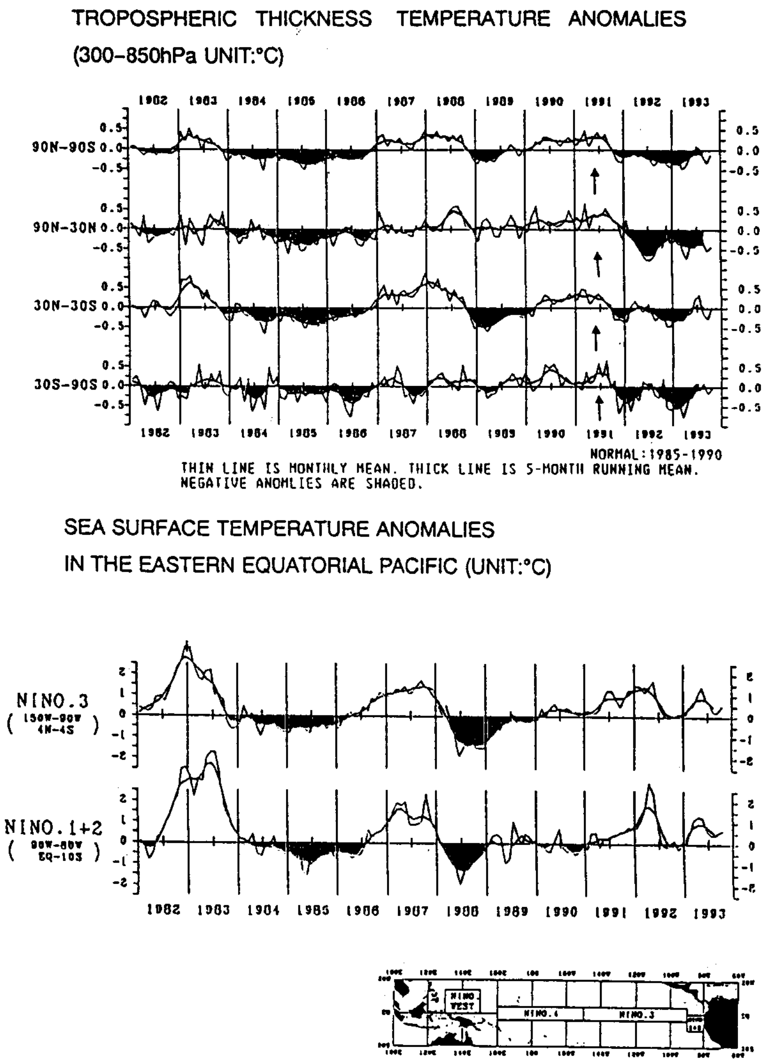

Fig.6 Tropospheric thickness temperature anomalies and sea surface temperature anomalies.

ACKNOWLEDGEMENTS

The another would like to express his special thanks to all members of the EPIC project funded by STAJ.

REFERENCES

1) Smithsonian Institution, Bull. GVN, 16, No.5, 2(1991).
2) Bluth et al., Geophys. Res. Lett., 19, 15(1992).
3) M. P. McCormick and R. E. Veiga, ibid, 19, 55(1992).
4) Shibata et al., ibid, 21, 197(1994).
5) Nagai et al., J. Meteor. Soc. Japan, 71, 749(1993).
6) Uchino et al., ibid, 71, 285(1993).
7) Read et al., J. Geophys. Res., 20, 1299(1993).
8) Kawamata et al., J. Meteor. Soc, Japan., 70, 1161(1992).
9) K. Kodera, J. Geophy. Res., 99, 1273(1994).
10) Johnston et al., GRL, 19, 211(1992).
11) Hofmann et al., ibid, 21, 653(1994).