GEOPHYSICAL RESEARCH LETTERS, VOL. 8, NO. 1, PAGES 63-65, JANUARY 1981

LIDAR DETECTION OF VOLCANIC AEROSOLS IN THE ATMOSPHERE FOLLOWING THE MOUNT ST.HELEN ERUPTION

Alfonso D'Altorio and Guido Visconti

Istituto di Fisica,Università dell'Aquila,67100 L'Aquila,Italy

Giorgio Fiocco

Istituto di Fisica,Università di Roma,00185 Roma,Italy

Abstract. We report lidar measurements of the aerosol content of the atmosphere for the first two months following the volcanic eruption of Mt.St.Helen.The measurements were taken near L'Aquila(Italy) with a lidar system utilizing a 50cm diameter telescope.The measurements are compared to similar data for the previous quiescent period and show a large increase of the backscattering ratio in the stratosphere and upper troposphere.Layers have been observed at various altitudes.A strong layer at 10-14Km has been observed only initially.Layers between 14-25Km have been observed continually.These features show a considerable day to day variability.

Volcanic explosions may determine detectable perturbations of the climatic system(Pollack et al.1976,Hansen et al. 1978,Fiocco et al.1977).Lidar systems have been used to monitor the stratospheric content of aerosols and give valid information about spreading and transport of the volcanic dust(Cadle et al.1976).Such measurements were performed by Fiocco and Grams(1964) and Grams and Fiocco(1967) following the Mt.Agung eruption and more recently by Russel and Hake(1977),McCormick and Fuller(1975) and McCormick et al. (1978) after the Volcan de Fuego eruption. In this letter we report lidar observations of the particulate content of the stratosphere and upper troposphere for the first two months following the volcanic explosion of Mt.St.Helen(46.2°N, 122.2°W) on May 18,1980.Such observations were carried out at Preturo,near L'Aquila Italy(42°N,23°E).

The main parameters of the lidar system are given in Table 1.The lidar utilizes a 0.4Joule Rhodamine 6G dye laser and has been typically operated at the wavelength of 589nm with a pulse repetition rate of 5 per minute.The receiver is a 0.5m diameter Cassegrain telescope.The system uses a chopper wheel to eliminate the backscattered light from the lowest altitudes.This procedure gives most of the data for altitudes above 12Km.Below this level additional data were collected without the wheel but including neutral density filters to reduce the amount of light incident on the photomultiplier.The data are collected with a Biomation Model 802 transient recorder typically with a 2 us time resolution resulting in a 300m vertical resolution.Data are processed and stored by a microcomputer by taking into account an average transmission function.The backscattering ratio is obtained with the usual method of comparing the expected molecular return with the lidar signal.

TABLE 1. System parameters for the lidar

Transmitter	
Operating wavelength	589 nm
Output energy/pulse	0.4 joule
Spectral width	10 nm
Laser	Dye laser flashlamp pumped Candela SL-100
Collimating telescope	6X,5cm diameter
Receiver	
Telescope	0.5 m Cassegrain
Spectral resolution	10 nm
Detector	EMI 9558 photomultiplier,cooled
Data acquisition	
Transient recorder	Biomation 802, 1024 channels
Microcomputer	Hewlett Packard 9825

Paper number 80L1482.
0094-8276/81/0080L-1482$01.00

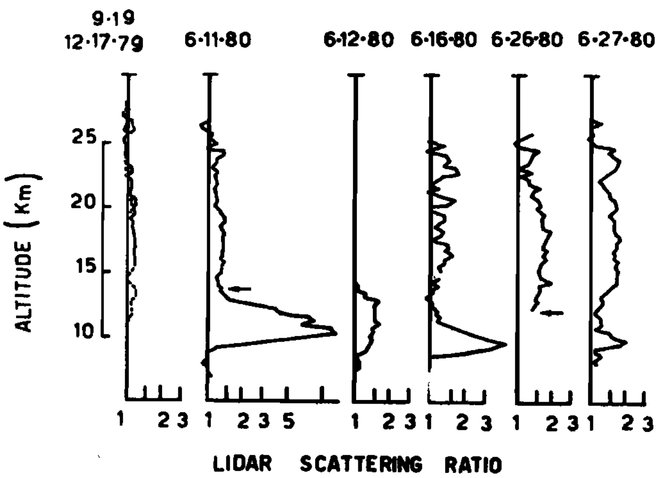

Fig. 1. Vertical profiles of lidar scattering ratio for the period June 11 to June 26,1980.The first profile shows the typical backscattering observed at the end of 1979.The dotted profile has been obtained with a dye laser operated at 450nm.For some of the profiles the tropopause position is indicated by an arrow.

Because of weather conditions early observations were not possible and the first night available was on June 11,1980. Fig.1 and 2 show a series of profiles of the backscattering ratio (total backscattering/molecular backscattering) taken from June 11 to July 15.Each profile is the result of averaging over 150shots at high altitude and 60 shots at low altitude.Also shown for comparison are three averaged profiles taken during a quiescent period at the end of 1979 from September to December.In one of these measurements the wavelength was 450nm.These 1979 data show a backscattering ratio in the stratosphere less than 1.2 which is regarded to be somewhat above the values for the unperturbed stratosphere.These results may be due to the particulate material from the eruptions of La Soufriere in April 1979 on the Island of St.Vincent (13°N,61°W) and of Sierra Negra in the Galapagos Islands(0.8°S,91.2°W)on 13 November 1979.

On June 11 a large echo was observed between 9 and 14Km with a backscattering ratio of about 11 accompanied by a significant increase in the stratosphere with a ratio up to 1.4.The lower layer which was located just below the tropopause,as determined by the nearest sounding at Fiumicino Airport(Rome),reappeared on another occasions although less intensely. It is worth pointing out that the heaviest dust cloud produced by the explosion was observed leaving the East Coast of the United States toward the Atlantic on May 27 in two main layers between 12-14Km and around 16Km(M.P.McCormick,personal communication).The location of this layer at our site can be related to the position of the jetstream as deduced by the available meteorological data. On June 12 deterioration of weather precluded high altitude observations.

Data on subsequent nights show a considerable increase of the aerosol load in the stratosphere.This is presumably due to the different modalities of the transport as well as to formation of aerosol particles from the gas phase(Toon et al. 1978).In particular layers can be frequently observed between 20 and 25Km,corresponding to the region where most of the photochemical aerosol are expected to originate.The day to day variability of the dust distribution and intensity of backscattering signal is also noteworthy. Some of these high altitude features have been observed also for the Volcan de Fuego eruption(Russel and Hake,1977;McCormick et al.1978).

In conclusion a considerable increase in the aerosol load has been observed for the first two months following the large eruptionof Mt.St.Helen.A distinct layer structure was observed including a 10-14Km layer with a large backscattering ratio which has subsequentely decayed.A broad layer between 14 and 20Km with a backscattering ratio of approximately 2 and a high altitude ,very sharp,layer between 20 and 25Km with a backscattering ratio between 4 and 10 have been continually observed.

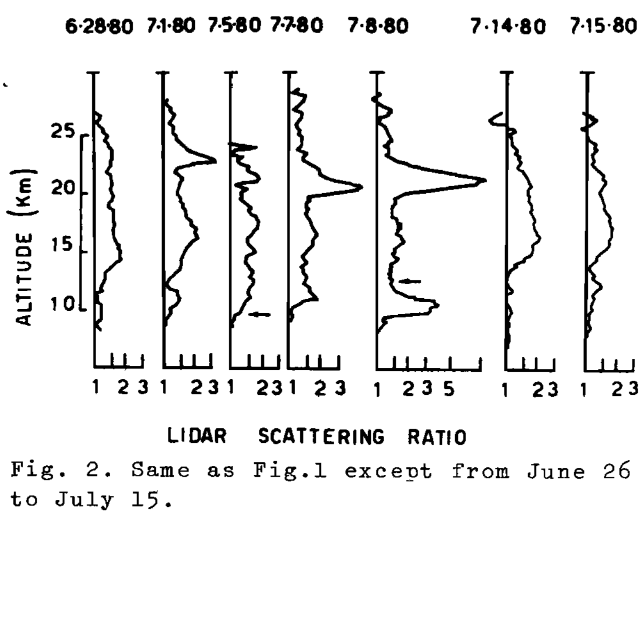

Fig. 2. Same as Fig.1 except from June 26 to July 15.

Acknowledgments. A few persons contributed to the good operation of the lidar system. In particular Dr.Sergio Ravarino took charge of most of the electronic and computer interfacing. This work is partly supported by Consiglio Nazionale delle Ricerche of Italy, "Programma Finalizzato Ambiente".

References

Cadle,R.D.,K.S.Kiang and J.F.Louis,The global scale dispersion of the eruption clouds from major volcanic eruptions,J.Geophys.Res., 81,3125-3131,1976.

Fiocco,G.,G.Grams and A.Mugnai,Energy exchange and equilibrium temperature of aerosols in the Earth's atmosphere,in Radiation in the Atmosphere,H.J.Bolle Ed.,Science Press,1977.

Fiocco,G. and G.Grams,Observations of the aerosol layer at 20Km by optical radar, J.Atmos.Sci.,21,323-324,1964.

Grams,G. and G.Fiocco,The stratosphere aerosol layer during 1964 and 1965, J.Geophys.Res.,72,3523-3542,1967.

Hansen,J.E.,W.C.Wang and A.A.Lacis,Mount Agung eruption provides test of a global climate perturbation,Science,199, 1065-1068,1978.

McCormick,M.P. and W.H.Fuller,Lidar measurements of two intense stratospheric dust layers,Appl.Opt.,14,4-5,1975.

Pollack,J.B.,O.B.Toon,C.Sagan,A.Summers, B.Baldwin and W.Van Camp,Volcanic explosions and climatic change: a theoretical assessment,J.Geophys.Res.,81, 1071-1083,1976.

Russel,P.B. and R.D.Hake Jr,The post-Fuego stratospheric aerosol:lidar measurements with radiative and thermal implications,J.Atmos.Sci.,34,163-176,1977.

Toon,O.B.,R.P.Turco,P.Hamill,C.S.Kiang, and R.C.Whitten,A one-dimensional model describing aerosol formation and evolution in the stratosphere:II sensitivities studies and comparison with observations,J.Atmos.Sci.,36,718-736,1979.

(Received August 5, 1980;
accepted October 17, 1980.)