28PA3

THE DISTRIBUTION OF AEROSOL IN THE ARCTIC STRATOSPHERE DURING THREE WINTERS AFTER THE ERUPTION OF MT. PINATUBO

Wolfgang Renger, Martin Wirth
Institut für Physik der Atmosphäre, DLR
Münchner Str. 20, D-82230 Oberpfaffenhofen, Germany
Phone: +49 8153 28 2580 Fax: +49 8153 28 1841

Introduction

The predominant feature in stratospheric aerosol during the last three winters was the huge amount of material brought into the atmosphere by the Pinatubo eruption from June to August 1991 at 15°N, 120°E. This contribution is discussing the structure of the polar vortex and especially its boundary region, as it showed up in the distribution of the aerosol and the decrease of the total aerosol loading over these three years.

For the purpose of studying the dynamics of stratospheric aerosol and ozone a combined aerosol and ozone LIDAR, named OLEX was developed at the DLR, Institute of Atmospheric Physics, as a contribution to the German Stratospheric Ozone Research Project. It is an airborne instrument that permits the recording of two-dimensional backscatter profiles at three different wavelengths (532 nm, 354 nm and 308 nm). From these profiles it is possible to calculate the spatial distribution, backscatter ratios and (assuming an aerosol model) extinction coefficients of stratospheric aerosols and clouds. In this paper we focus on the aerosol part.

During the last three winters the system was, among various other experiments, mounted on a C160-Transall aircraft. Based in Kiruna (northern Sweden 69°N 20°E), a total of 73 flights with almost 500 flight hours was performed in various campaigns from December to March in the years 91-94. The investigated area extended from the west coast of Greenland (50°W) to Novaja Semlja (50°E), up to 85°N and down to 17°N.

Experimental Setup

The aerosol part of the OLEX system utilizes the frequency doubled and tripled light of a Nd:YAG laser. With this system it is possible to achieve output energies of 100 mJ at 532 nm and 120 mJ at 354 nm simultaneously at a repetition rate of 10 Hz. The receiver optics consist of a 35 cm Cassegrain-telescope and a three-channel optical filter bank based on dielectric beam splitters and band pass filters. Photomultiplier tubes operating in current mode are used for detection. The analog signals are digitized by a four-channel oscilloscope and stored on an optical disk for later analyses.

The vertical resolution of the system was designed to be 12 m, later reduced to 48 m by digital filtering. The horizontal resolution is about 12 m for a single shot assuming a typical aircraft speed of 125 m/s. The signal to noise ratio of a single backscatter signal is sufficient for the detection of the geometrical properties of the aerosol layer such as the thickness and the altitude or the wavelength of mountain PSC's. For a precise calculation of the scattering ratio and the optical thickness 2000 shots are averaged, giving a horizontal resolution of about 25 km. Useful data can be obtained from 10 km to 27 km, geometric altitude.

Data Evaluation

We present plots of the total backscatter ratio β/β_R. For the determination of β_R we calculated the molecular density of the air from ECMWF-analyses supplied by NILU (Norwegian Institute for Air Research) and the DMI (Danish Meteorological Institute).

The LIDAR equation was inverted using an iteration scheme that assumes a constant ratio of the extinction to the backscatter coefficient α_M/β_M (the LIDAR ratio) for the present aerosol particles. Since it is not possible to determine the LIDAR ratio with a conventional backscatter LIDAR, we estimated the mean value and the variability of this quantity by performing Mie calculations based on particle size distribution data of T. Deshler measured during the EASOE 91/92 campaign at Kiruna. Based on these calculations we have chosen a value of $\alpha/\beta = 25sr$ for the inversion calculations at 532 nm. This relative low value is also supported by Raman LIDAR measurements, see Ferrare et al. [1992]. Since the total optical thickness of the stratospheric aerosol layer was about 0.1 in 91/92 , an uncertainty of 50% in the LIDAR ratio leads to a maximum error of about 5% in the backscatter values.

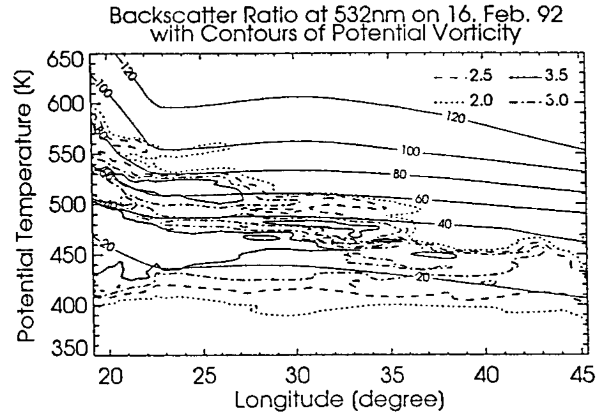
Observations and Discussion

The main results of this three year observation period are summarised as follows:

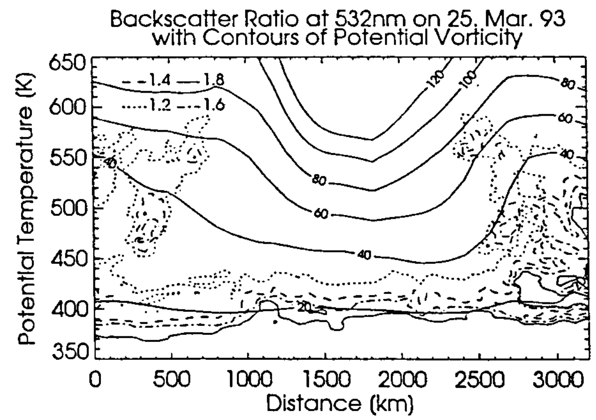
- The peak aerosol backscattering dropped by a factor of $\approx$3 from year to year. Since the wavelength dependence of the backscattering has not changed considerably, the particle size distribution should have been constant. So the optical thickness also dropped by a factor of 3 from year to year. The top layer of the Pinatubo aerosol reached an altitude of 23-25 km in all winters (outside the polar vortex). The lower bound extended down to the tropopause in the last two winters wereas in the 91/92 winter there often was a gap of about 2-3 km in between.

- The polar vortex was *free* (that means $\beta_{Mie} < 5\%$ of the value outside the vortex)of aerosol throughout the whole winters down to a level of about 430K potential temperature. Below that level the aerosol layers were horizontallly very homogeneous, not showing any correlation to the vortex edge.

- The top layer of the aerosol in the region of the polar vortex dropped down with an averidge velocity of about 80m/day until end of January. A further sedimentation of the aerosol below a level of 430 K was not observed, so we conclude that there is a more rapid exchange of air between various latitudes below this level.



Contour plot of the backscatter ratio for a flight from Kiruna to Novaja Semlja on 16. Feb. 92.



Contour plot of the backscatter ratio for a flight from Kiruna to Spitzbergen and back again on 25. Mar. 93.