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Solid and Liquid Particles of Polar Stratospheric Clouds Observed by Lidar at Ny-Ålesund, Spitsbergen

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1. Introduction

In order to observe tropospheric and stratospheric aerosols in arctic, a polarization lidar was installed at Ny-Ålesund, Norway (78.6°N, 11.5°E) in January 1994. We have carried out lidar measurement every winter, and observed many events of polar stratospheric clouds (PSCs).

Many investigations have suggested that PSC particles should be subclassified as type I or type II, depending on their formation temperature and chemical composition.[1,2] Type II PSCs are composed of crystalline water ice when stratospheric temperatures drop below the frost point of water (~188K). Type I PSCs which form at temperature several degrees warmer than the ice frost point (~195K), are composed of mainly HNO_3 and H_2O. Type I PSCs were once thought to be solid particles like NAT (nitric acid trihydrate).[3] Recently, many studies for type I PSCs, however, have shown that it is possible to form liquid particles of PSCs, such as a $HNO_3/H_2SO_4/H_2O$ ternary solution.[4]

The total backscattering ratio (R_T) and the total depolarization ratio (δ_T) are simultaneously obtained from polarization lidar data. The value of R_T is proportional to total amount of particles, and δ_T gives us the average qualitative information of the phase of PSC particle. When PSC particles are spherical (liquid) or non-spherical (solid), the depolarization ratios of the particles are zero or a positive number, respectively. We observed liquid and solid PSC particles by lidar at Ny-Ålesund. [5,6]

On the assumption that depolarization ratio of the group of solid PSCs has the identical value, we obtain the backscattering ratio of solid and liquid PSCs, (R_{solid} and R_{liquid}), that is, quantitative information. This paper shows vertical structure, time variation of R_{solid} and R_{liquid}, and the relationship between backscattering ratio of each PSC particle and temperature.

2. Lidar used for Measurements

The lidar transmits two wavelengths (1064nm and 532nm) of a flash lamp pumped Nd:YAG laser. The laser beam at 532nm was linearly polarized. The characteristics of the system are shown in Table 1.

The total backscattering ratio (R_T), the total depolarizat6ion ratio (δ_T), and wavelength dependence of R_T (α) are obtained by this lidar system.

The backscattering ratio of solid and liquid PSCs, (R_{solid} and R_{liquid}) is calculated from R_T and δ_T, on the assumption that the depolarization ratio of the group of solid PSCs is 35%, and that of liquid PSCs is 0%.

Wavelength	1064nm	532nm
Pulse Energy	200mJ	50mJ
Pulse Repetition	10Hz	
Telescope (Schmidt-Cassegrain)	35cm (stratosphere) 20cm (troposphere)	
Lidar parameters	R_T	R_T, δ_T
	α_T	

Table 1: Specifications of lidar system at Ny-Ålesund, Norway (78.6°N, 11.5°E)

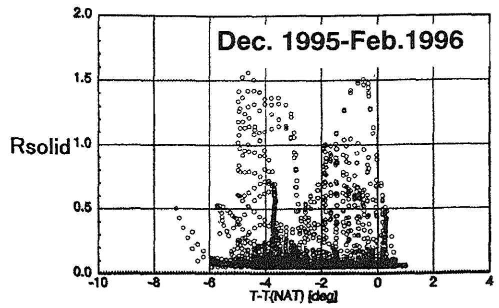

Fig. 1: The relationship between R_{solid} and T-T(NAT) in the R_{solid} rich case. [T(NAT) is NAT frost point]

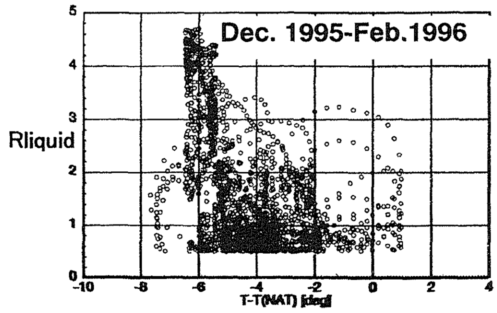

Fig. 2: The relationship between R_{liquid} and T-T(NAT) in the R_{liquid} rich case. [T(NAT) is NAT frost point]

3. Results

Figure 1 shows the relationship between R_{solid} and temperature in the R_{solid} rich case (R_{solid}=large and R_{liquid}~zero). This result suggests that R_{solid} do not increase above NAT frost point.

Figure 2 is the R_{liquid} rich case (R_{solid}~zero and R_{liquid}=large). The value of R_{liquid} of the almost plots increase below several degrees colder than NAT frost point. This temperature is similar to the temperature at which ternary solution particles grow rapidly.

Acknowledgements

We wish to thank Kings Bay Kull Company (KBKC) for supporting our measurements at Ny-Ålesund, Norway.

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