ARCTIC CLOUD AND AEROSOL OBSERVATIONS USING A MICRO-PULSE LIDAR IN SVALBARD

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1. INTRODUCTION

In the polar region as well as in other places on the earth, clouds play an important role in radiation balance of the global climate system. However, it is generally known that detection of polar clouds is difficult from satellite-borne passive sensors. Also ground-based observations of clouds are spatially limited particularly in the polar regions, and sometimes the reliability is poor.

The National Institute of Polar Research (NIPR) promotes atmospheric research in both Arctic and Antarctic regions. In the Arctic, NIPR has started an international program for aerosol-cloud-radiation studies based at Ny-Alesund (78° 56'N, 11° 52'E), Svalbard (Fig.1). For ground-based remote-sensing and in-situ measurements, NIPR has placed cloud and aerosol observation systems, including a Micro-pulse Lidar (MPL), at the Rabben Observatory, a Japanese research base in Ny-Alesund. Based on preliminary analysis of the MPL data, features of Arctic clouds and the spring haze will be shown and performance of MPL for cloud and aerosol measurements will be discussed in this paper.

2. MICRO-PULSE LIDAR

The Micro-pulse Lidar (MPL) is an eye-safe maintenance-free lidar system that has been originally developed by Spinhirne (1993) in order to acquire long-term datasets of backscatter profiles of aerosol and clouds. MPLs with the same concept and design as the original are commercially available from SESI, USA. We employed an MPL system made by SESI and placed the MPL in the Rabben Observatory. Specification of the SESI MPL system is shown in Table 1.

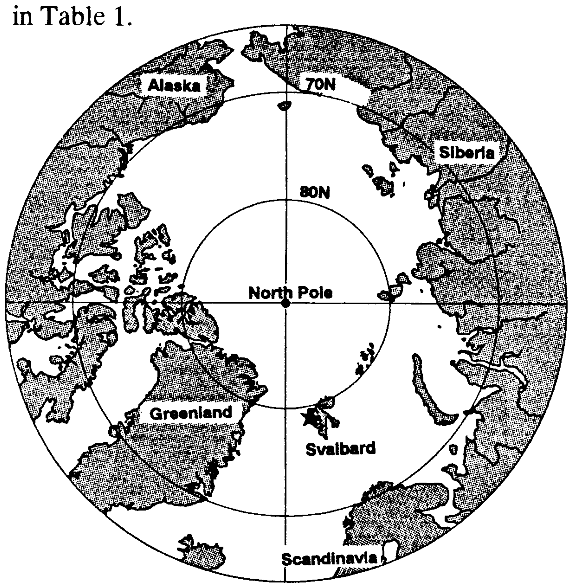

Fig. 1 Geography of the Arctic and the location of Ny-Alesund (★).

Table 1 SESI Micro Pulse Lidar System
(Science & Engineering Service, Inc., MD, USA)

Laser	Diode-laser-pumped Nd:YLF laser
Wavelength	523 nm
Pulse energy	5 μJ
Pulse frequency	2500 Hz
Pulse duration	10 nsec
Range resolution	30 m
Beam divergence	1.2 mrad
Telescope	20-cm diam., f10, Schmidt-Cassegrain
Transmitter field of view	50 μrad
Receiver field of view	100 μrad
Detector	Geiger-mode Avalanche photodiode

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3. OBSERVATION

The MPL measurement at Rabben started in 1998. The telescope of MPL for laser emission and return signal receiver is declined at 34 deg. of the zenith angle and looking up through a glass window of the observatory building. The measurements are acquired on a continuous basis with 2-minute intervals for normal operations. Data are transferred by ftp via Internet, and the status of measurements is monitored in Japan.

4. RESULTS AND DISCUSSION

Figure 2 shows time-altitude color map of the backscatter signal for the period of 3 – 10 March, 1998 when an airborne observation campaign called AAMP98 was carried out over Svalbard (Shiobara et al, 1999). Figure 3 shows the time series of backscatter ratio from 16UTC of 6 March to 08UTC of 7 March 1998, including a dissipation process of high altitude clouds at 7 – 8 km (yellow and orange colored). A haze layer, where the backscatter ratio was 1 – 1.5 (light blue), still remained at the same height after the cloud disappeared. For the AAMP98 campaign, the airborne optical particle counters measured high number concentrations at the 7–8 km height layer when the AAMP aircraft was descending to Longyear Airport in Svalbard at 9:30UTC, 7 March (Shiobara et al., 1999). This fact indicates that MPL is a powerful instrument for measuring the tropospheric aerosols as well as clouds.

The second topic is the climatology of cloud base height (CBH) in Svalbard. The MPL had been operated continuously for six months at Ny-Alesund. It is relatively easy for lidars on the ground to detect the cloud base height. The SESI MPL system includes the CBH analysis and produce CBH data in real time basis. Figure 4 shows the monthly frequency of CBH appearance in July – December 1999. The climatology of CBH shows a feature of Arctic boundary layer clouds with CBHs below 2km in summer and early autumn. On the other hand, higher clouds were rather dominant in late autumn and winter.

5. SUMMARY

MPL is a powerful instrument for long-term observations of haze layers as well as clouds. An interaction process of aerosol and cloud was observed from precise analyses of the MPL backscatter profiles. Results from a 6-month acquisition of MPL at Ny-Alesund, Svalbard showed seasonal variation of cloud appearance and cloud base height. Long-term data sets from the MPL measurements will contribute to the Arctic cloud climatology and the Arctic haze study for climate application.

Acknowledgments

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References

Shiobara, M., Y. Fujii, S. Morimoto, Y. Asuma, S. Yamagata, S. Sugawara, Y. Inomata, M. Watanabe, and T. Machida, 1999: An overview and preliminary results from the Arctic Airborne Measurement Program 1998 campaign. *Polar Meteorol. Glaciol.*, 13, 99-110.

Spinhirne, J.D., 1993: Micro pulse lidar. *IEEE Trans. Geosci. Remote Sens.*, 31, 48-55.

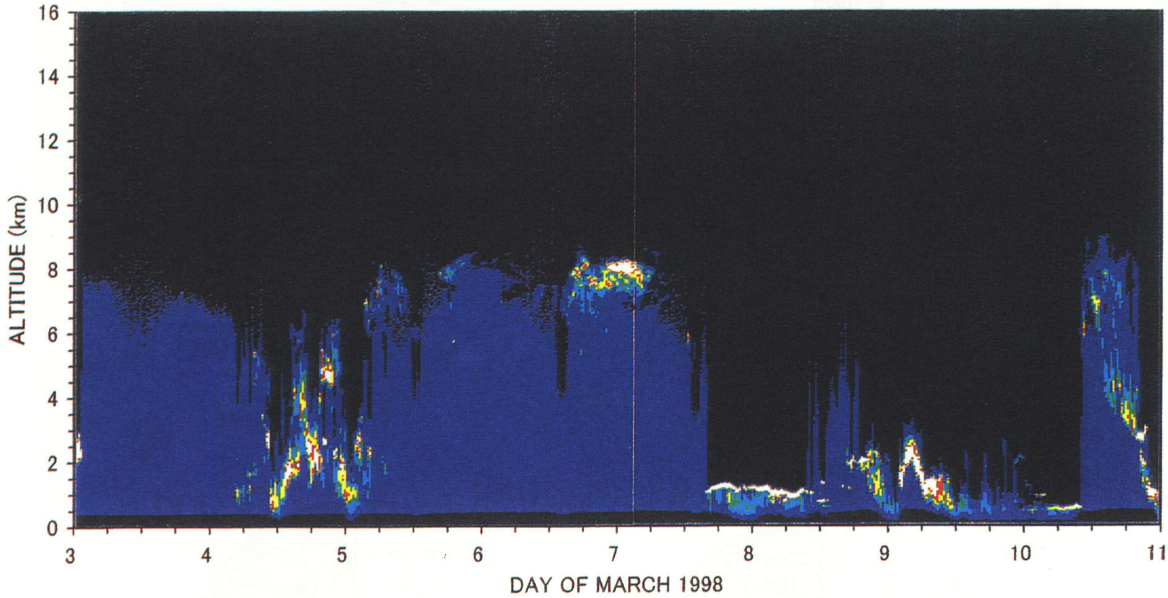

Fig. 2 Time-altitude color map of the MPL backscatter signal measured at the Rabben Observatory, Ny-Alesund, 3-10 March 1998.

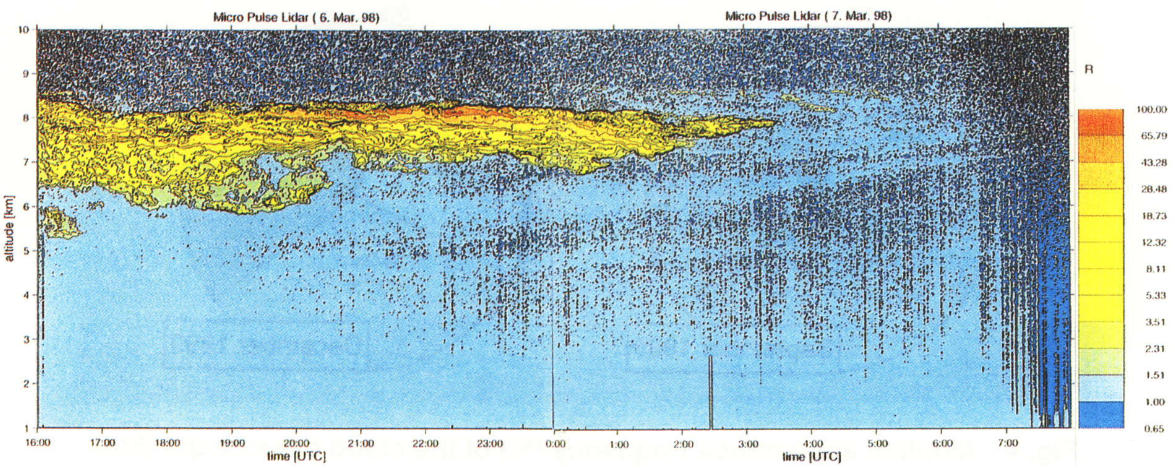

Fig. 3 Time-altitude color map of the backscatter ratio from 16UTC of 6 March to 8UTC of 7 March 1998. Original data are the same in Fig. 2.

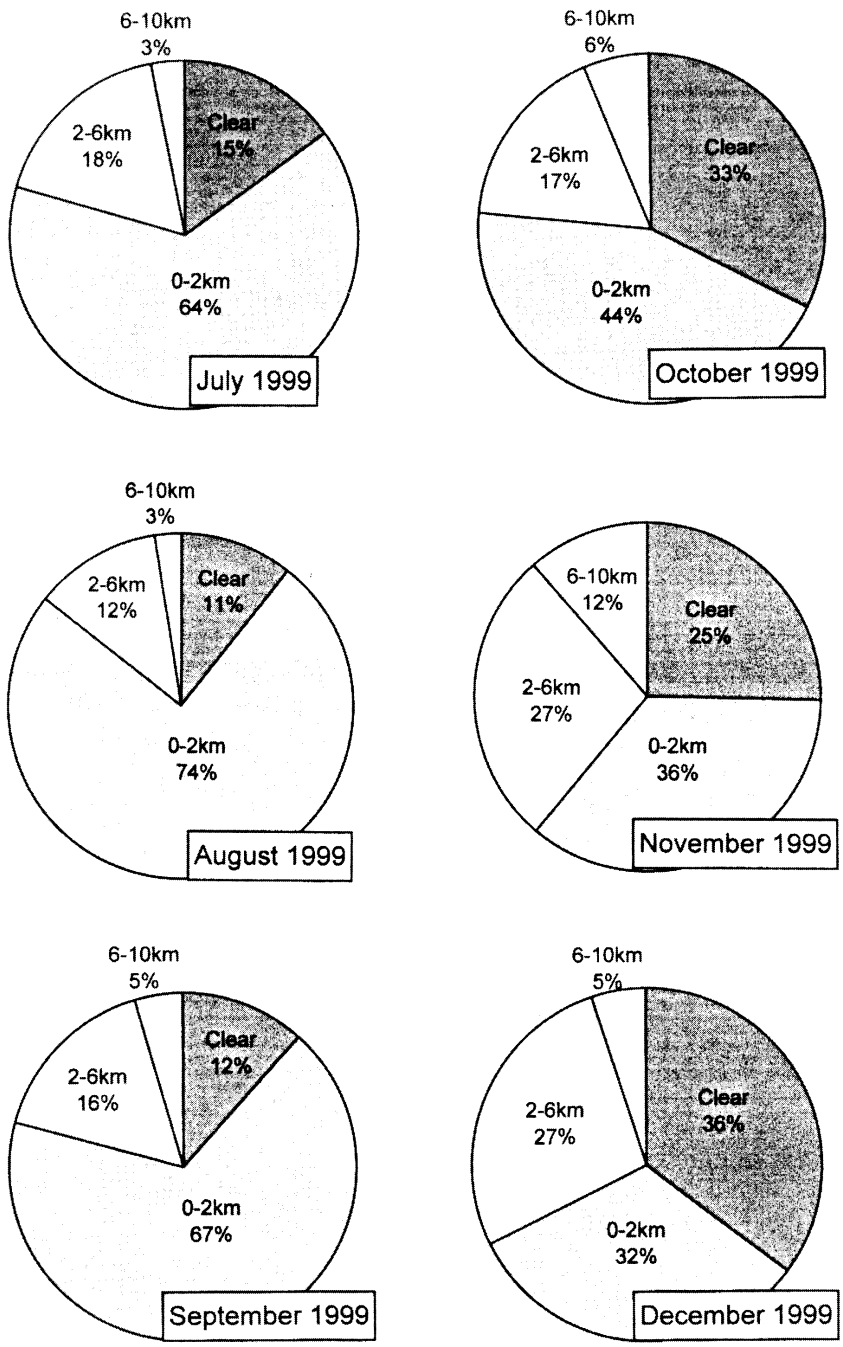

Fig. 4 Monthly appearance frequency (%) of the cloud base height (km) detected by MPL at Ny-Alesund for July – December 1999.