Low Altitude Ice-cloud Measurement by In-line type Micro Pulse Lidar

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Abstract
Low altitude ice-cloud measurement was demonstrated by the in-line type micro pulse lidar system. Low altitude ice-crystal is the important meteorological parameter associated with lightning stroke and heavy rain. We evaluated the lidar echoes from the ice-clouds in the viewpoints of the configuration of the ice-crystals, the depolarization effect, and the snowfall case.

1.Introduction

It is interesting to explore the mechanism of steep change of local weather; lightning stroke and heavy rain. Monitoring ice-crystals in clouds is effective to grasp their activities. It is known that the ice-crystal has the depolarization effect against the beam incidents at a slant. There are plural reports trying to distinguish spherical particles (cloud particles) and non-spherical particles (ice-crystals) by analyzing the lidar echo's depolarization[1]. However, Multiple scattering of spherical particles also occurs the depolarization. Many reports underspecify the distinction.

In this study, the in-line type micro pulse lidar (MPL) has been developed for the disaster prediction[2]-[4]. Near range depolarization measurement was achieved to use the common optics for the transmitter and the receiver. The receiver's field of view (FOV) of 0.1mrad is enough narrow to eliminate the multiple scattering echo light. The developed lidar was eye-safe owing to the enlargement of the transmitting beam (annular beam of the telescope's aperture size). The transmitting beam is linearly polarized as *p*-component. Applying the optical circulator, the system can receive the depolarized echo caused by ice-crystals separately due to its polarization. The in-line type MPL makes possible the low altitude ice-cloud measurement by the above techniques. This report states the topical results.

2. Low altitude ice-cloud measurement

(i) In-line type MPL system

The in-line type MPL system is shown in Fig.1. The optical circulator and a pair of Axicon prisms for the annular beam substantialized the in-line optics. The power of the transmitting beam was 40μJ. The LD pumped YLF laser had the repetition frequency of 1-10kHz. The echo was evaluated by the average of 100-2000 shots. The detector was analog mode APD with a peltiert device and a cooling fan. Currently to expand the observation area, the system was put in the observation room. As the telescope tube carried all of the optics, the observation could be conducted in arbitrarily angle from the zenith to the horizontal in the western sky.

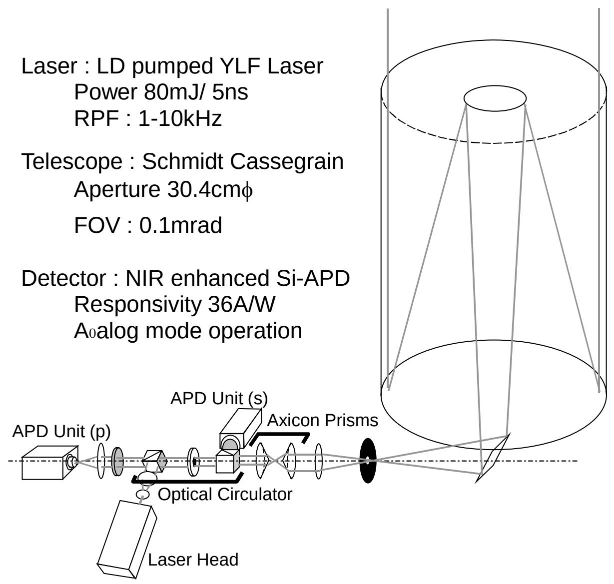

Fig.1 In-line type MPL system.

(ii) Observation

Figure 2 shows the observation results of ice-clouds. Figure 2(a) shows the typical ice-cloud echo. The observation angle was 20 degrees from the zenith. The lidar echoes of both *p*- and *s*-components were observed. In the case of the water cloud observation, there is no signal in the *s*-component. The cloud base temperature at the altitude of 550m was suggested "below zero" even though the ground temperature was 16 degrees. We considered that it was caused by the air current from the upper atmosphere. It links to the next discussion.

Figure 2(b) shows the s-component lidar echo on the zenith angle observation. The ice-crystal has the hexagonal structure, and it floats horizontally in general[5]. The incident beam's polarization was never changed by the crystal's horizontal plane. In the case that the ice-crystals were inclined by the air current, the incident beam was depolarized by them. The tilt angle of the ice-crystal was estimated as 5.7 degrees by the depolarization ratio of Fig.2(b). In the observation, *s*-component echo was billowed. It means that the air current inside cloud is reflected in the s-component echo.

Figure 2(c) is the snowfall data observed at the angle of 30 degrees from the zenith. There were 2 peaks in both *p*- and *s*-component lidar echoes. The lower peak was the snowfall echo because it changed billowy. The upper peak was the snow cloud. From the aspect of the backscattering characteristics of snow crystal, it was interesting that *s*-component echo was higher than *p*-component echo. The propagation distance in snow cloud was about 400m. It is larger than the usual propagation distance (300m) in typical water cloud. It suggests that the large snow crystal has the large reflection with the depolarization effect, while its density is low.

3. Summary

The low altitude ice-cloud was observed by the in-line type MPL. We monitored the depolarization effect of the near distance ice-cloud. It was difficult for the usual lidar to distinguish the ice-crystal especially in the near range. Low altitude ice-crystal is the important meteorological parameter associated with the lightning stroke and heavy rain. Currently the developed MPL system is in year-round observation. The statistical analysis to evaluate the lidar echoes from the ice-crystals is under way in not only the winter season measurement, but also rainy season, and thundercloud measurements.

Reference

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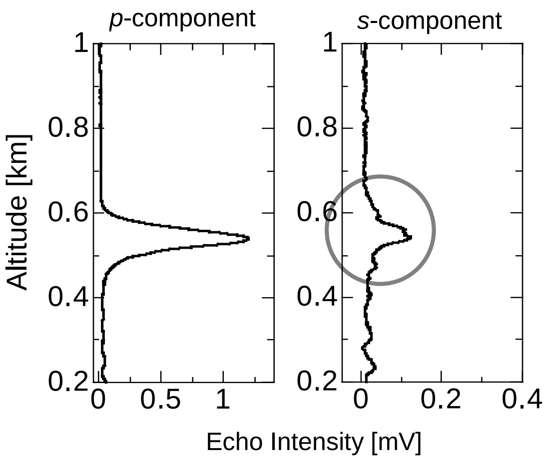
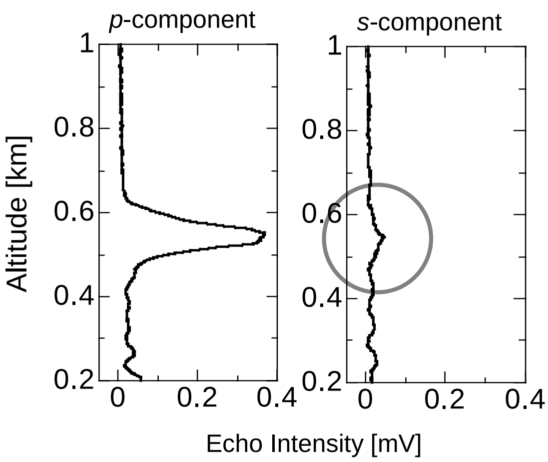
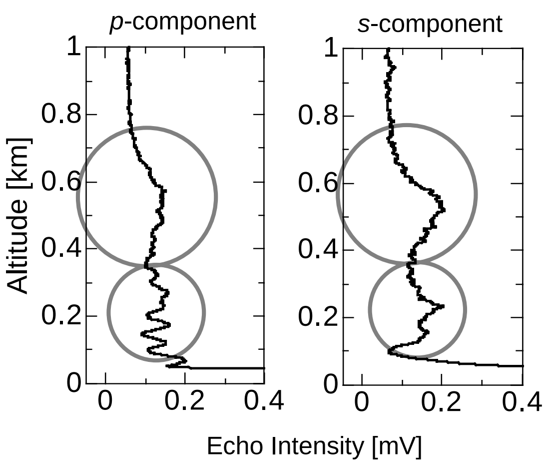


(a)18:32, Nov. 14, 2005. Temp. 16 deg. Hum. 65% Ice Cloud.



(b) 18:56, Nov. 14, 2005. Temp. 16 deg. Hum. 65% Ice Cloud.



(c) 18:56, Dec. 13, 2005. Temp. 8 deg. Hum. 44% Snowfall

Fig.2 Ice cloud Measurement.